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ORIGINAL ARTICLES.

I.—A New Devonian Trilobite and Lamellibranch from Cornwall.

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(By permission of the Director of the Geological Survey.)

(PLATE III.)

During the present survey of Cornwall Mr. Clement Reid has discovered several interesting fossils which provide a substantial addition to the previously recorded Devonian fauna of that part of the country. The forms described below were found by Mrs. Clement Reid, to whose patience and skill I am also indebted for the developing of the best parts of the specimens. My best thanks are due to my colleague Mr. H. H. Thomas for the accompanying drawings of the two forms.

Phacops (*Trimerocephalus*) *pentops*, sp. nov. (Pl. III, Figs. 1–4.)

Description.—The *cephalon* is obtusely round in front, with gentle lateral curvature, slightly indented where the dorsal furrows bounding the glabella reach the margin. The surface is covered with fine granules of fairly equal distribution. The sub-marginal sulcus is well marked, broader towards the front, and gradually diminishes in width as it follows the narrow marginal border towards the genal extremities. The length to breadth = 2 : 3.

The *glabella* (Pl. III, Fig. 2) is pentagonal in general outline, tumid, protuberant, and overhanging at an angle of about 70° to the plane of the dorsal surface. The length of the frontal lobe to breadth = 3 : 4. The first pair of lateral furrows is not discernible; the second pair is seen faintly by strong magnification; the third lateral furrows are deep, and bound a well-defined basal lobe with a small tubercle at each extremity. There are indications of a groove across this lobe. The deep dorsal furrows separating the glabella from the cheeks form an angle of about 81° with each other. The occipital furrow is narrow and deep, with a fairly conspicuous and elevated occipital ring, adorned by a tubercle at each end.

The *cheek-areas* are triangular, slightly tumid, and bounded towards the margin of the head-shield by a narrow border, which is continued under the overhanging frontal lobe of the glabella.

The *eyes* (Pl. III, Figs. 1, 2, 4), of which only the left one is preserved in the specimen, are placed upon narrow free cheeks, roughly rectangular in shape and lying at the anterior extremity of the fixed cheeks. The facets, which are fully developed, are arranged in a single row on a narrow sub-crescentic ridge, making a small angle with the border. They are five in number, circular, and slightly diminishing in size in either direction from the central facet. There is a possible trace of a terminal rudimentary sixth facet.

Thorax.—The *axis* is well defined, convex, with sub-parallel margins, and slightly tapering towards the pygidium. The bounding dorsal furrows are broadly deep. The segments, some of which are not preserved, are slightly tuberculate at the sides. The *pleura* are flattened and abruptly deflected backwards and downwards at the fulcrum about two-thirds their width from the axial furrows, and are grooved from the axis outwards, the anterior segment overlapping at the deflected portion.

The *pygidium* (Pl. III, Fig. 3) is small in proportion to thorax. The length to breadth = 2 : 5. The *axis* is prominent, convex, and gradually tapering to a blunt end posteriorly. The number of annulations is about six, and they become more weakly marked and obsolete towards the posterior extremity. The *pleura* are slightly flattened. The annulations are broadly rounded, faintly grooved, and curved slightly backwards. A marginal border is not developed.

Dimensions.—The length of the head-shield = 2·2 mm.; the breadth of the head-shield = 3·3 mm.; the greatest breadth of the thorax = 3·1 mm.; the length of the pygidium = 0·8 mm.; the breadth of the pygidium = 2·0 mm.

Locality and horizon.—One very small rolled-up specimen of this Trilobite was found in a band of highly fossiliferous grey slates, probably under 20 feet in thickness, exposed between the tide-marks on the east side of Portquin Harbour and not far from the beach. It is preserved in iron pyrites, and occurs together with a good assemblage of small mollusca, similarly preserved: *Tornoceras simplex*? (v. Buch), *Torn. verneuili* (Münst.), *Torn.* cf. *subundulatum*, Frech, forms near to *Torn. globosum* (Münst.) and *Torn. planilobum* (G. & F. Sandb.), *Orthoceras* sp.; small Gasteropods, *Naticopsis* spp., *Platyostoma* sp., *Bellerophon* (*Ptomatis*?) sp.; a few Lamellibranchs, *Buchiola retrostriata*? (v. Buch), and *Allorisma concinna*, sp. nov. A fragment of a Trilobite showing a part of the thorax and pygidium occurs also in the material; it probably belongs to the same species as the one described.

The assemblage of Cephalopods points to an undoubted Upper Devonian age, while the occurrence of forms near to *Tornoceras planilobum*, *Torn. verneuili*, and *Torn. globosum*, which, with others, have been placed by Professor Frech (6,[1] p. 125; 7*a*, p. 67) under a new genus, *Cheiloceras*, appears to support a middle Upper Devonian horizon. This *Cheiloceras* horizon was first noticed near Brilon by Professor Kayser (11,[1] pp. 602 ff.), who named the beds "Nehdener Schiefer". They lie at the base of the Clymenien-Kalk and are rich in Goniatites preserved in iron pyrites. The same definite horizon has been recognized by various investigators at Elsterburg in Thuringia,

[1] These figures refer to Bibliography at end of paper.

Langenaubach near Haiger, Germany, Kielce in Poland, Rostellec near Brest, Cabrières in south of France, and apparently also in the Ural District (10, pp. 155, 156; 16*a*, p. 184). Dr. R. Wedekind has recently discussed and subdivided this horizon in an interesting contribution entitled "Die Cephalopodenfauna des höheren Oberdevon am Enkeberge" (17, pp. 565–634).

Remarks.—The employment of the name *Trimerocephalus* in the above description is in accordance with the usual interpretation. Professor Gürich would base the distinction between the typical *Phacops* and *Trimerocephalus* on the size of the angle made by the dorsal furrows bounding the glabella, which in the case of *Trimerocephalus* would be about 50° and *Phacops* 80°–90° (9, p. 362). I agree with Mr. Cowper Reed that this distinction is quite insufficient (15, p. 226). The subgenus was originally founded by M'Coy (12, p. 404) upon *Trinucleus ? lævis*, Münst. (13, p. 116, pl. x, fig. 6), a form in which he considered the eyes to be absent. Gümbel (8, pl. A, figs. 7–9) refigured Münster's original, and identified it with *Phacops cryptophthalmus*, Emmrich (2, pp. 27, 61). Münster's figure is too poor to be of use, while Emmrich's rather scanty description is unaccompanied by illustrations.

The poor state of preservation of thorax and pygidium prevents as clear a discrimination of certain parts of our species as could be desired. In the general shape of the head-shield it resembles *Phacops cæcus*, Gürich (9, pp. 362, 363, pl. xv, fig. 4), from the middle part of the Upper Devonian of the north-east border of Kadzielnia, Poland, a form which has also been described by Dr. Drevermann from the Clymenien-Kalk of Langenaubach (1*c*, pp. 114, 115, pl. xiii, fig. 4). *Phacops cæcus* differs, however, among other respects, in the absence of eyes, in the presence of a broader border and a broader occipital ring, in the possession of more extended postero-lateral margins of the head-shield, a greater angle between the dorsal furrows bounding the glabella, and a less tumid frontal margin of the glabella.

Phacops (*Trimerocephalus ?*) *lotzi*, Drevermann (1*c*, pp. 117, 118, pl. xiii, fig. 7), also bears a superficial resemblance to the form described. The eye in Dr. Drevermann's species differs in the possession of eight facets arranged in two rows, while the marginal border is broader, the postero-lateral margin of the head-shield more extended posteriorly, the frontal margin of the glabella more angular, and the angle of the dorsal furrows bounding the glabella smaller.

The Portquin species differs from Gümbel's figure of *Phacops cryptophthalmus*, Emmrich (= *T. ? lævis* of Münster), in the relative proportions of the length and breadth of the head-shield, in the narrower occipital ring and marginal border, and the different arrangement and smaller number of eye facets.

In describing *Phacops* (*Trimerocephalus*) *lævis* (Münst.), as a synonym with which both he, M'Coy, and Gümbel place *Calymene lævis* of Phillips (14, pp. 129, 130, pl. lv, fig. 250), Salter states that the "eyes are absent in our English specimens but probably present in perfect individuals" (16, p. 17). It is possible that in many cases the apparent absence of eyes is accounted for by the poor state of preservation.

Phillips has recorded *Phacops* (*Trimerocephalus*) *lævis* (Münst.) under

the name *Calymene lævis* from Brushford (North Devon), Mudstone Bay, Durlstone, Knowle Quarry near Newton Bushel (South Devon) (14, p. 130). Salter questions, however, the occurrence at Mudstone Bay and Durlstone (16, p. 17).

Mr. Howard Fox has collected the same species from Trevone Bay, Cornwall (4, p. 543), and forms doubtfully referred to *lævis* from Cant Hill, St. Minver, Cornwall (3, p. 52; 18, p. 154), and near Porthmissen beach, Cornwall (5, p. 6).

A poorly preserved specimen of a form which somewhat resembles *Phacops* (*Trimerocephalus*) *anophthalmus*, Frech (7, p. 270), has been found by Mr. H. Dewey at Daymer Bay, Cornwall (H. D. 111, Geol. Surv. Coll.), while *Ph.* (*Trim.*) cf. *anophthalmus* was collected by Mr. J. Pringle at the same locality and horizon (Pr. 4733, Geol. Surv. Coll.). Specimens collected by Mr. W. A. E. Ussher at Whiteway Farm, Devonshire, in 1888, were then determined as *Phacops cryptophthalmus*, Emmrich. A re-examination of one of these specimens (22884) justifies its determination as a form closely related to that figured by Gümbel.

Allorisma concinna, sp. nov. (Pl. III, Figs. 5 and 6.)

Description.—This shell is fairly globose, equivalve, very inequilateral, and is much produced posteriorly, the posterior portion, measured from the intersection of the axes, being about twice the length of the anterior. The angular umbones lie far forward, and bend over prominently above the hinge-line. The hinge-line is straight posteriorly, but curves slightly downwards in front of the umbones. Behind and under the umbones lies a small, elongated, narrow ligamental area, gradually tapering posteriorly. A low keel runs from behind the umbo towards the posterior margin of the valve, and is separated from the hinge-line by a narrow, almost smooth, groove, gradually flattening and widening posteriorly. A very obtuse and indistinct keel or fold passes forward from the umbo to the antero-ventral margin. The ornamentation consists of prominent, subconcentric, regular ridges, lessening in number and lying further apart towards the ventral margin. The ridges commence indistinctly anteriorly to the umbo, and after a regular curvature round the obtuse anterior fold run in shallow curves towards the posterior hinge-line. They become indistinct at the low posterior heel. Under a strong lens the best preserved portions of the shell exhibit finer reticulate ornamentation, the components of which are respectively concurrent with and approximately at right angles to the stronger ridges. No traces of internal parts are to be seen.

Dimensions.—Length, 13·5 mm. approx.

Height, measured at the umbo, 7·5 mm.

Locality and horizon.—The same as for the above-described species.

Remarks.—Some little variation is exhibited in the specimens obtained, though these points do not seem to suffice for specific distinction. Thus, two examples [C.R. 1521, 1672] show irregularity in their ornamentation, one ridge occasionally dividing locally into two parts. One of these specimens [C.R. 1521] also possesses more ridges within the same space than the typical form.

I do not know any Upper Devonian *Allorisma* which suggests close relationship to this species. The nearest resemblance is afforded by *Allorisma münsteri* (d'Arch. & de Vern.) as figured by Professor Beushausen from the Middle Devonian of Germany (1*b*, p. 255, pl. xxv, figs. 4, 5). Our form differs, however, from this in being considerably smaller, in the valves being less globose, in the more gradual fall from the umbo posteriorly and the less prominence of the umbo above the hinge-line, in the narrower shape of the posterior ligamental area, the straightness of the hinge-line posterior to the umbones, and the presence of the fainter reticulate ornamentation.

Professor Beushausen's figures differ from those given by d'Archiac and de Verneuil (1*a*, p. 376, pl. xxxvii, figs. 3, 3*a*) in the sharper fall of the shell anteriorly to the umbones, as well as in the less elongated shape.

After examination of a poor specimen from Breiniger Berg, doubtfully referred to *Allorisma münsteri*, Beushausen suggests the possibility of this form ranging into the Upper Devonian (1*b*, p. 256).

LIST OF WORKS CITED.

1*a*. Archiac, A. d'. and Verneuil, E. de.—"On the Fossils of the Older Deposits in the Rhenish Provinces": Trans. Geol. Soc. London, 1842, ser. II, vol. vi.

1*b*. Beushausen, L.—"Die Lamellibranchiaten des rheinischen Devon mit Ausschluss der Aviculiden": Abhdl. geol. Karte Preussen, 1895, N.F., xvii.

1*c*. Drevermann, F.—"Fauna der oberdevonischen Tuffbreccie von Langenaubach bei Haiger": Jahrb. d. K. preuss. geol. Landesanst., 1900, Bd. xxi.

2. Emmrich, H. F.—"Ueber die Trilobiten": Leonhard und Bronn, Neues Jahrb. f. Geologie und Petrefactenkunde, 1845.

3. Fox, Howard.—"Further Notes on the Devonian Rocks and Fossils in the Parish of St. Minver": Trans. Roy. Geol. Soc. Cornwall, 1905, vol. xiii, pt. i.

4. ——"On the Distribution of Fossils on the North Coast of Cornwall south of the Camel": ibid., 1901, vol. xii, pt. vii.

5. ——"On some Fossils from the Coast Sections in the Parishes of Padstow and St. Merryn": ibid., 1894.

6. Frech, F.—Lethæa Palæozoica, 1897, Bd. ii, Theil i.

7. —— Die Karnischen Alpen, 1894.

7*a*. ——"Über devonische Ammoneen": Beitr. z. Pal. und Geol. Österreich-Ungarns, etc., 1902, Bd. xiv.

8. Gümbel, C. W.—Geognostische Beschreibung des Fichtelgebirges, etc., 1879.

9. Gürich, G.—"Das polnische Mittelgebirge": Verhandl. d. Russ.-Kaiserl. Min. Gesellsch. zu St. Petersburg, 1896, Bd. xxxii.

10. Kayser, E.—Lehrbuch der Geologie, 1908, Theil ii.

11. ——"Ueber die Fauna des Nierenkalks vom Enkeberge, etc.": Zeitschr. d. d. geol. Gesellsch., 1873, Bd. xxv.

12. M'Coy, F.—"On the Classification of some British Fossil Crustacea, etc.": Ann. Mag. Nat. Hist., 1849, ser. II, vol. iv.

13. Münster, Georg von.—Beiträge zur Petrefactenkunde, 1842, v.

14. Phillips, J.—Palæozoic Fossils of Cornwall, Devon, and West Somerset, 1841.

15. Reed, F. R. C.—"Classification of the Phacopidæ": Geol. Mag., 1905, Dec. V, Vol. II.

16. Salter, J. W.—British Trilobites (Palæontogr. Society), 1864.

16*a*. Tschernyschew, Th.—"Die Fauna des mittleren und oberen Devon am Westabhang des Urals": Mém. du Com. géol. St. Petersburg, 1887, iii, No. 3.

17. Wedekind, R.—"Die Cephalopodenfauna des höheren Oberdevon am Enkeberge": Neues Jahrb. f. Min., etc., 1908, Beil.-Bd. xxvi.

18. Woodward, H.—"Trilobites from the Devonian of St. Minver, Cornwall": Geol. Mag., 1905, Dec. V, Vol. II.

EXPLANATION OF PLATE III.

Phacops (*Trimerocephalus*) *pentops*, sp. nov.

Devonian: Portquin Harbour, Cornwall.

Fig. 1.—Head-shield (× 10).
,, 2.—Side view showing the fall of the frontal portion of the glabella and the position of the eye (× 10).
,, 3.—Pygidium and part of thorax (× 10).
,, 4.—An enlarged view of the left eye showing the arrangement of the facets (× 20).

The original is in the Geological Survey Collection [23068].

Allorisma concinna, sp. nov.

Fig. 5.—Side view (× 2).
,, 6.—Dorsal view (× 2).

The original is in the Geological Survey Collection [23078].

II.—The 'Trias' of Moray.

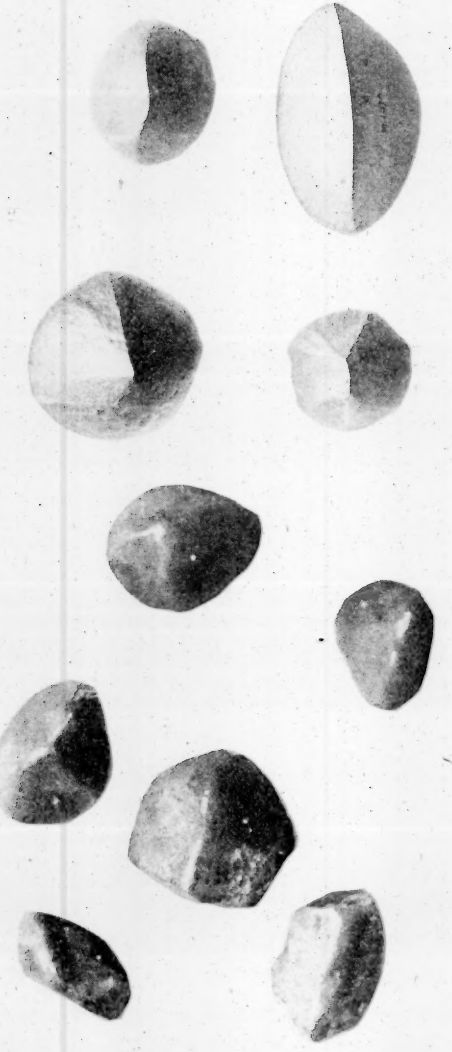
By D. M. S. Watson, B.Sc., Beyer Fellow of the Manchester University.

(PLATE IV.)

THE Reptiliferous Sandstone of Moray first attracted attention in 1851, on the discovery in it by Patrick Duff of a skeleton of *Telerpeton elginense* at Spynie. This was described by Mantell (17),[1] but did not raise any doubts as to the age of the bed in which it was found, which was at that time universally regarded as Upper Old Red Sandstone. This opinion was not disturbed until Huxley showed that *Stagonolepis Robertsoni*, Ag., was a crocodilian, the allies of which were of Triassic age (9); when Huxley showed that *Hyperodapedon* occurred in the undoubted Trias of Coton End, near Warwick (11), the point was generally regarded as settled. Meanwhile some foot-prints had been found by Captain Brickenden (6) at Cummingstone, near Elgin, which were recognized by Huxley to be similar to those described by Sir William Jardine from Annandale. The discovery by C. Moore (19) that the well-known quarry at Linksfield, formerly supposed to be in rocks of Wealden age, was really opened in beds of Rhætic age appeared to be a strong argument in favour of the Triassic age of the reptile-bearing beds. It had, however, already been shown by Hugh Miller (18) that this mass was really a boulder resting on an ice-scratched surface of the subjacent rocks, hence the evidence drawn from the occurrence of this mass is quite inconclusive. The discovery by Professor Judd (15) that a small patch of a rock identical in physical characters with the cherty rock of Stotfield existed on the north side of the Moray Firth, which was conformably covered by an unfossiliferous series of beds which graded up into the Lower Lias, afforded further evidence of the correctness of Huxley's conclusions as to the age of these beds.

Meanwhile another series of reptiles had been found at Cutties Hillock Quarry, and in a trial pit below them the Upper or Rosebrae Beds of the Upper Old Red Sandstone were proved and yielded a specimen of *Holoptychius nobilissimus*, Ag., now in the Elgin

[1] These numbers in parenthesis refer to the Bibliography at end of paper.



Series 1. Six wind-cut pebbles from Permian of Quarry Wood, Elgin, Moray.

Series 2. Four wind-cut pebbles from North Island, New Zealand, for comparison with the Elgin series.

Museum. An inconsiderable bed of pebbles was regarded by Professor Judd as marking the base of the reptile-bearing beds (16).

The Cutties Hillock reptiles were fully described by E. T. Newton (20), who showed that they represented a fauna entirely different to that of the ordinary *Stagonolepis* Sandstone of the district. He, however, continued to regard the beds as Triassic.

More reptiles have been since described by Newton and Smith Woodward from the quarries of Lossiemouth and Spynie (21, 23).

The Reptiliferous Sandstone of Moray occupies three quite distinct areas, which do not touch and whose relative ages can hence never be determined by stratigraphy. These patches are—

1. The Cutties Hillock area. This occupies the top of Quarry Wood Hill to the east of the town of Elgin; this area is about three-quarters of a square mile in extent, and is exposed in several quarries, of which only that of Cutties Hillock has yielded any fossils. The rock is a coarse sandstone often containing inconstant bands of pebbles, usually not more than 8 inches in thickness. They are much false-bedded; the real bedding is probably nearly horizontal, although in one quarry the apparent dip is about 30° to the south-west.

The resemblance between these beds and the Upper Old Red on which they rest is fairly close, but the latter is usually much finer and seldom, if at all, contains pebble bands; this account only refers to the Rosebrae Beds which form the base of the Quarry Wood Hill. The pebbles in the Cutties Hillock Beds are all of characteristically wind-cut shapes, and good 'Dreikanters' are quite common (see Plate IV, series 1). The sand grains are rounded and the whole deposit is pretty obviously of desert origin; judging from the appearances presented by the whole series of quarries, the surface on which the reptile-bearing sandstone was deposited was an irregular one, although I have not seen a really satisfactory exposure of the junction. This area is entirely surrounded by Upper Old Red Sandstone and lies practically entirely above the 300 feet contour.

2. The Lossiemouth area. This forms a large patch east of 321 Q extending from the coast at Lossiemouth towards Elgin and eastward for about 3 miles. It is exposed in the quarries at Spynie, Lossiemouth, and Findrassie Wood. Its base is nowhere seen, but at the East Quarry at Lossiemouth there is a small exposure of soft, fine-grained, yellow sandstone, which greatly resembles some types of the Rosebrae Beds of the Upper Old Red. It has, however, yielded no determinable fossils. At the Little Skerries at Branderburgh a dark-red rock comes to the surface which is quite distinct from the Reptiliferous Sandstone, and in which it is stated that scales of *Holoptychius* have been found. The relation of this mass to the Trias is not, however, clear, and it is very probably brought up by faulting.

The typical character of this series of beds is that of a fine, fairly soft sandstone, nearly white in colour, with no pebbles and no distinct bedding; it is, however, very strongly jointed. This rock is said to be overlaid at Stotfield by "the Cherty rock of Stotfield," a curious, apparently chemical, deposit, the origin of which it is not easy to ascertain. The real relations of the cherty rock and the Lossiemouth Sandstone are, however, not easy to establish. At the upper quarry

at Spynie there occurs a very hard white quartzite, which appears to be an altered portion of the ordinary Reptiliferous Sandstone which is worked in the quarry just below. This rock yielded one of the skeletons of *Scleromochlus Taylori*, recently described by Dr. Smith Woodward. It has, however, been confused with the Stotfield rock, with which, I believe, it has nothing whatever to do. At Findrassie Wood Quarry this type of Reptiliferous Sandstone approaches to within 1½ miles of the Cutties Hillock type, but is only 80 feet above sea-level.

3. The Cummingstone area. This extends along the shore from Burghead to Coversea, and is very well exposed in the cliffs as well as the quarries at Cummingstone. The rock is a moderately coarse, false-bedded sandstone, with occasional thin beds of small pebbles, which appear to be of the ordinary water-worn type. The deposit is very false-bedded; there is apparently a steady dip of about 40° to the south-west for about 3 miles of coast, whereas the real dip is quite small and probably variable in direction. The beds are sometimes flaggy, and in that case contain considerable numbers of tracks of reptiles. At Coversea this type of rock comes to within 2 miles of that of the Spynie type.

The Cutties Hillock Quarry has yielded the following reptiles:—

Gordonia Juddiana, E. T. Newton, and four other species of the genus.
Geikia Elginense, E. T. Newton.
Elginia mirabilis, E. T. Newton.

None of these reptiles have ever been found elsewhere, but their allies are known in the Karroo of South Africa (the age of which is also uncertain), in India in beds of uncertain age, and in Texas and Russia in beds that are undoubtedly Permian (1, 2, 3, and 7).

Elginia is allied to *Pariasaurus*, which has been found by Professor Amalitzky in the Permian of Russia, and of the Cotylosauria found by Professor Cope in the Permian of Texas and other North American localities. *Gordonia* is a close ally of *Dicynodon*, which also occurs in the Permian of Russia. *Geikia* is allied to *Ptychognathus* of the Karroo, which occurs there with *Dicynodon*.

The Lossiemouth Beds yield a completely different fauna, of which fairly numerous examples have now been found. These are as follows:—

Dasygnathus longidens, Hux.
Telerpeton Elginense, Mantell.
Hyperodapedon Gordoni, Hux.
Stenometopon Taylori, Boulenger.
Stagonolepis Robertsoni, Ag.
Erpetosuchus Grantii, E. T. Newton.
Ornithosuchus Woodwardi, E. T. Newton.
Scleromochlus Taylori, A. S. Woodward.

The affinities of *Dasygnathus* are uncertain; it appears to me, however, to be a Labyrinthodont, and large examples of this group are common in the Trias.

Telerpeton is a small Anomodont allied to *Procolophon* of the Karroo.

Hyperodapedon Gordoni has been found in the undoubted Trias of Coton End, near Warwick; it occurs in the Spynie and East Lossiemouth Quarries.

Stenometopon is a Rhynchocephalian so far only found in the West Quarry at Lossiemouth; it is obviously fairly closely allied to *Hyperodapedon*.

Stagonolepis and *Erpetosuchus* belong to the exclusively Triassic group of the Parasuchia, which is of very wide distribution, being well represented in Germany and the United States.

Stagonolepis has occurred at Findrassie Wood Quarry at Spynie and East Lossiemouth.

Erpetosuchus has been found at West Lossiemouth and probably also at Spynie.

Ornithosuchus and *Scleromochlus* are by some regarded as Dinosaurs, and by another important group of palæontologists as belonging to Owen's group, the Thecodontia, which is nearly the same as Huxley's Parasuchia. Neither group, however, is known to occur in rocks older than the Trias.

In addition, at least three undescribed genera of reptiles occur at West Lossiemouth. These appear to me to be either Dinosaurs or Thecodonts, of one of which there is a somewhat obscure skeleton in the Manchester Museum, presenting resemblances to *Aetosaurus*.

Taken as a whole, this fauna is undoubtedly Triassic in its affinities, and the fact that most of its members have now been found in at least two localities suggests that we now have a reliable knowledge of the general character of the fauna.

The Cummingstone area has not yet yielded any fossils except footprints. During my visit I saw tracks of four or five types, all agreeing, however, in general character. They are double tracks, the right and left feet being widely separated when compared with the stride. The manus and pes are of approximately the same size, and are impressed to about the same extent. I was seldom able to count the number of toes; in those cases where I did so they were five in number. The feet are short and brachydigitous, and in certain cases, at any rate, were provided with claws, which the animal sometimes dragged along, producing a pronounced scratch before the actual print. These tracks differ entirely in type from all Triassic ones with which I am acquainted, but they resemble entirely the tracks in the Permian Sandstone of Mansfield, Nottinghamshire, one of which was recently described by Mr. G. Hickling, in whose company I saw in the quarry at that place some four or five other species of tracks. Similar types of footprints have been found in the Permian of Thuringia, and it seems that such tracks are always of Permian age. The track that Huxley described (14), which is now in the Jermyn Street Museum, seems to be identical with one from the Permian of Mansfield, of which I possess a specimen. This track was regarded by Huxley as possibly belonging to *Stagonolepis*, an idea which must be given up, for the metapodial subsequently described by Huxley indicates an elongated foot. Of the Lossiemouth reptiles *Hyperodapedon* alone remains for examination. Its foot seems more suitable, but examination of a well-preserved foot in the Elgin Museum seems to show that it even is too long to produce the Moray tracks. It is unfortunate that amongst the Cutties Hillock fossils no complete foot is known, but the fragments known in *Gordonia Traquairi* (?), consisting of short and stout metacarpals and phalanges, suggest that the foot was similar to that of the allied *Dicynodon*, of which a specimen was figured by Owen in his Catalogue of Fossil Reptiles from South

Africa, and later in the Quarterly Journal of the Geological Society (22); this foot seems quite competent to produce the prints in question, and the characters of the humerus of *Gordonia* seem to indicate great breadth of track, one of the most characteristic features of the prints under consideration. The known *Dicynodon* foot is pentadactyl, so that no objection can arise on that score. It seems, therefore, that the Cummingstone rocks are to be associated with the Cutties Hillock group rather than with the Lossiemouth Trias, and that both are really Permian.

In the field one gains the impression that the New Red Sandstone rocks of Moray are not of great thickness, but on account of their constant false-bedding and isolated exposure (except in the case of the Cummingstone group) it is impossible to give actual measurements. I believe that 200 feet will cover the thickness of the Lossiemouth group, 120 feet more the Cutties Hillock rocks, and probably 400 or 500 feet the Cummingstone Beds.

The present relationships of the beds are easiest accounted for by faults, and Judd has already pointed out that evidence of faulting exists in the neighbourhood. One fault of considerable throw must run easterly and westerly through the village of Quarrywood to throw the Permian Cutties Hillock Beds up to a height of some 200 feet above the Triassic Lossiemouth Beds of Findrassie Wood Quarry, and another with general north and south direction of similar throw must be invoked to separate the Permian Cummingstone Beds at Coversea from the Lossiemouth Beds at Stotfield.

It appears to me that the footprint-bearing beds of Annandale must also be regarded as Permian, as the tracks from that locality described by Sir W. Jardine are of the well-defined type which occurs at Mansfield; some of the tracks, in fact, seem to be identical.

Summary.—It is pointed out that there are three types of Reptiliferous Sandstone in the neighbourhood of Elgin—the Lossiemouth Beds, the Cutties Hillock Beds, and the Cummingstone Beds, and that there is no stratigraphical evidence of their mutual relations. It is pointed out that whilst the Lossiemouth Beds contain an undeniably Triassic fauna, the Cutties Hillock Beds contain a completely different assemblage of reptiles, much akin to the Permian fauna of Texas and Russia. The Cummingstone Beds have yielded only footprints, but these are of the well-defined type occurring in the Permian of Mansfield and Thuringia. It is shown that these tracks could not have been made by *Stagonolepis* or *Hyperodapedon*, the two possible reptiles of the Lossiemouth Beds, but that they agree well enough with the foot of *Dicynodon*, an ally of *Gordonia*, one of the Cutties Hillock reptiles, whose foot, judging from the fragmentary remains alone known, must have greatly resembled it.

It is suggested that the Cutties Hillock Beds and the Cummingstone Beds are of the same age, and that they are really Permian and not Trias, as has formerly been supposed.

I wish to express my indebtedness to William Taylor, Esq., J.P., of Lhanbryde, on whose list of the localities of Lossiemouth Bed fossils (5) my own is largely founded, and to Dr. W. Mackie, of Elgin, the first to call attention to the desert evidences in the Cutties Hillock Beds.

To Mr. G. Hickling I am indebted for much information with regard to Permian footprints.

BIBLIOGRAPHY.

1. Amalitzky, V. 1900. Soc. Imp. des naturalistes a St. Petersbourg. December 28, 1899.
2. —— 1900. Review of the above. By G. J. H.: Geol. Mag., Vol. XXXVIII, p. 231.
3. —— 1901. Compte Rendus de l'Academie des Sciences, tome 132, p. 591.
4. Boulenger, G. A. 1904. "Some Reptilian Remains from the Trias of Elgin": Phil. Trans., 196, B, p. 175.
5. Boulenger, G. A.
6. Brickenden, R. T. 1852. "Discovery of Reptilian Foot-tracks and Remains in the Old Red or Devonian of Moray": Q.J.G.S., vol. viii, pp. 97–100, pl. iii.
7. Gase, C. E. "A Revision of the Pelycosauria of North America": Carnegie Institution, Pub. No. 55, 1907.
8. Hickling, H. G. A. 1906. "On some Footprints from the Permian of Mansfield": Q.J.G.S., vol. lxii, p. 125.
9. Huxley, T. H. 1859. "On *Stagonolepis Robertsoni*, Ag., of the Elgin Sandstone and Footmarks in Sandstone of Cummingstone": Q.J.G.S., vol. xv, p. 440, pl. xiv.
10. —— 1867. "On a New Specimen of *Telerpeton Elginense*": Q.J.G.S., vol. xxiii, p. 72.
11. —— 1869. "On *Hyperodapedon*": Q.J.G.S., vol. xxv, p. 138.
12. —— 1875. "*Stagonolepis Robertsoni* and the Evolution of the Crocodilia": Q.J.G.S., vol. xxxi, p. 423, pl. xix.
13. —— 1887. "Further Observations on *Hyperodapedon Gordoni*": Q.J.G.S., vol. xliii, p. 675, pls. xxvi and xxvii.
14. —— "*Stagonolepis Robertsoni*": Mem. Geol. Surv. Eng., Mon. 3.
15. Judd, J. W. 1873. "The Secondary Rocks of Scotland": Q.J.G.S., vol. xxxix, p. 97, pl. vii.
16. —— 1885. "The Relation of the Reptiliferous Sandstone of Moray to the Upper Old Red": Proc. Roy. Soc., No. 24, p. 394.
17. Mantell, G. A. 1852. "On the Impression of a Skeleton of a Reptile from the Old Red Sandstone of Spynie, near Elgin": Q.J.G.S., vol. viii, p. 100.
18. Miller, H. "The Voyage of the Betsy."
19. Moore, C. 1860. "The so-called Wealden of Linksfield and the Reptiliferous Sandstone of Elgin": (Abs.) Q.J.G.S., vol. xvi, p. 445.
20. Newton, E. T. 1893. "On some New Reptiles from the Elgin Sandstones": Phil. Trans., vol. 184, B, p. 431.
21. —— 1894. "Reptiles from the Elgin Sandstone. Description of two new Genera": Phil. Trans., vol. 185, B, p. 573.
22. Owen, R. 1880. "Description of parts of the Skeleton of an Anomodont Reptile (*Platypodosaurus robustus*, Owen) from the Trias of Graaff Reinet, S. Africa": Q.J.G.S., vol. xxxvi, p. 424.
23. Woodward, A. S. 1907. "On *Sclerosuchus Taylori* from the Trias of Elgin": Q.J.G.S., vol. lxiii, p. 140.

EXPLANATION OF PLATE IV.

Series 1.—Six pebbles from the Permian of the Quarry Wood group. They exhibit characteristically wind-cut shapes, despite the rounding off of their angles. From a quarry 150 yards to the east of Cutties Hillock. In the Manchester Museum.

Series 2.—Four pebbles from the surface, Waitotara Grand Flats, North Island, New Zealand. These should be compared with those from the Elgin rocks represented below. In the Manchester Museum.

III.—Fossil Representatives of the Lithodomous Worm *Polydora*.

By Dr. F. A. Bather, M.A., F.G.S., Brit. Mus. (Nat. Hist.).

THE borings of the Polychæt Annelid *Polydora ciliata* (Johnston)[1] are familiar in limestone pebbles and the stouter mollusc-shells on our coasts, but shales and occasionally other rocks are not free from their attacks. They may be recognized by the double aperture, often loosely described as keyhole-shaped, leading to a U-shaped cylindrical tube. The union of the two apertures in a single depression, by the loss of the organically formed septum between them, produces a more slit-like opening, whereas if the surface of the pebble be further worn the two round holes are more clearly distinguished. The differences between the burrows of *Polydora* and those of other lithodomous Annelids, especially the associated *Dodecaceria*, were clearly stated by Dr. W. C. M'Intosh in a very full paper "On the Boring of certain Annelids" (1868, Ann. Mag. Nat. Hist. [4], ii, pp. 276–95, pls. xviii–xx).

The disintegrating action of these worms has been emphasized and its geological importance pointed out by several writers, among whom may be mentioned the Abbé Dicquemare (1781, Rozier's Obs. et Mém. Phys., Paris, pp. 222–4, xviii); Mr. (now Sir) E. Ray Lankester (1868, Ann. Mag. Nat. Hist. [4], i, pp. 233–8, pl. xi); and Professor L. Vaillant (1891, Ann. Sci. Nat. [7], xii, pp. 39–50). It would, therefore, be of some interest to trace the palæontological history of this lithodomous Annelid. According to the revisions by Dr. D. Carazzi (1893, Mitt. Zool. Stat. Neapel, xi, pp. 4–45, pl. ii) and by Mr. M. P. Mesnil (C. R. Acad. Sci., Paris, cxvii, pp. 643–5), there are from ten to fifteen species now living, but that which is of most importance as a borer, at least in north-western Europe, appears to be *P. ciliata*. This lives in the lower half of the littoral or, more strictly speaking, inter-tidal region, and its forsaken burrows may therefore throw light on the elevation or depression of the land. The existence of other species must, however, guard us against rashly referring to this species fossil borings of similar character.

Though, so far as I can ascertain, this genus has not hitherto been recorded in a fossil state, the collection of fossil Annelids in the British Museum enables us to carry the history of *P. ciliata* or an allied species back to the middle of the Pliocene. The following examples may be mentioned:—Borings in a valve of *Volsella modiolus* (Linn.), from the Glacial beds of the Clyde series; the borings fringe an area from which the outer layers of the shell have been broken [A 235].[2] A phosphatic nodule from the Red Crag of Suffolk, cut and polished and showing numerous tubes; in this the two limbs of the U are in many cases cut across, and each pair is enclosed by concentric layers of the concretion, forming a sort of figure of 8 [58197]. A similar nodule from Woodbridge, Suffolk [58220].

Samuel Woodward, on p. 20 of his "Outline of the Geology of

[1] I have to thank my colleague, Dr. W. T. Calman, for kindly referring me to this species and some recent papers on it.

[2] The relations of *Polydora* to recent oysters have been fully discussed by Professor M'Intosh (1902, Ann. Mag. Nat. Hist. [7], ix, pp. 299–308).

Norfolk" (1833), describes the denuded surface of the Chalk on which the Norwich Crag was laid down. He refers particularly to "a chalk-pit near Postwick church, the plateau of which, in its whole extent, is perforated by an animal of the Tubicolæ family, as the rocks of our present coasts are". Specimens of this old sea-floor collected at Postwick by Samuel Woodward himself show that the borings are similar to those of *Polydora*, though rather coarser than those of *P. ciliata*. In one specimen [A 275] the planed surface of the chalk is clearly seen, but the borings are concentrated so thickly in places as to have given rise to irregular cavities about a centimetre across; in another specimen [A 279] the chalk is so riddled that the planed surface is no longer to be detected. From the same locality comes a pebble formed from a Chalk fossil *Echinocorys*, and richly pierced with similar tubes [A 274]. These borings must have been made before the sea-shore was covered with the shell-beaches that now form the Norwich Crag. They may, therefore, be regarded as of Plaisancian rather than Astian age.

Since these borings can only be expected in strictly littoral deposits, such as are rarely preserved through a long period of geological time, it is natural that traces of the genus should not have been observed in the older Tertiary and the Mesozoic rocks of Britain. I cannot detect them, as I had hoped, in our specimens of *Ostrea bellovacina*, or in any of our *Serpula*-covered Cretaceous and Jurassic shells, except perhaps one. This is a *Gryphæa incurva* from the Sinemurian zone of *Arnioceras semicostatum* near Dorsington, Gloucestershire. [A 1183, R. F. Tomes Colln.] The surface of both valves is covered with numerous tubes of a small *Serpula*, and on the large valve are also several oval pits each apparently leading to a double tube. The length of the oval pit is only ·4 or ·5 mm., as compared with 1·5 to 2 mm. in *Polydora ciliata*, and the burrows are perhaps more likely to be those of a *Dodecaceria*. The specimen is merely mentioned here as affording the nearest approach to *Polydora* burrows that I have been able to find. All other specimens that are bored seem to have been attacked by anything rather than *Polydora*.

In view of this lack of evidence it was the more interesting to receive from Mr. Linsdall Richardson an enquiry regarding a bored pebble that he had extracted from the basal conglomerate of the Rhætic series at Hapsford Mill, Vallis, near Frome, Somerset. This is a grey limestone pebble of irregular shape, with extreme measurements 76 mm., 46 mm., and *circâ* 50 mm. Its exposed surface is almost entirely covered with borings which Mr. Richardson had already recognized as similar to those in a pebble of chalk from the sea-shore at Flamborough. The worm that made these may well have been a *Polydora*, but it was not *P. ciliata*, for the tubes are plainly larger and their openings seem to have been further apart. The diameter of the tubes in a recent specimen of *P. ciliata* is ·5 to ·6 mm.; in the Rhætic fossil, ·8 to ·9 mm. Until the need arises for discriminating between these Rhætic borings and others that may be found in rocks of approximately the same age, it scarcely seems advisable to invest them with the dignity of a new specific name.

Whether as a disintegrator of rocks or as an index to the former

relations of land and sea, *Polydora* has, it appears, sufficient importance to warrant the publication of this brief note, to the end that other field-geologists and collectors may keep their eyes open for such occurrences as the very interesting one made known by Mr. Richardson.

IV.—Hamster Remains from the Norfolk Forest Bed.

By E. T. Newton, F.R.S., F.G.S.

MR. A. SAVIN, of Cromer, has been kind enough to send me for examination a large number of small vertebrate remains which he has recently collected from the Upper Freshwater Bed of the Norfolk Forest Bed Series at West Runton. Among these there is one little specimen which deserves to be recorded, as it represents a genus not hitherto recognized in the 'Forest Bed'. The specimen is a right maxilla with three grinders in place, indubitably belonging to the genus *Cricetus*; in size it is distinctly larger than the common Hamster *Cricetus vulgaris* (= *C. frumentarius*), which is the largest species of the genus living at the present day. Only once before has *Cricetus* been recognized in Britain, W. A. Sanford[1] having identified from the Hutton Cave, Mendip Hills, remains of a small mouse-like species which he referred to *Cricetus songarus*.

Mr. Savin's specimen is a right maxilla, which, in its present condition, measures 14·5 mm. in length; it has the three molars in place and in an excellent state of preservation. Towards the front of the bone, on the outer side, is seen the base of the jugal process, and on the inner side the palatal plate, which, though not quite perfect, shows much of its oral surface and the floor of the right nasal passage. The greatest length of the crowns of the three teeth is 9·3 mm., the alveoli measuring a little more (10·3 mm.). The grinding surfaces of the teeth are just sufficiently worn to show their patterns in a remarkably clear manner (see Figure), and when examined with a strong lens, or, better still, with a low power under the microscope, the series of islands formed by the enamel, which extend along the middle of each tooth, form a very striking feature. One's attention is also attracted to the deep and sharply defined pits, which are seen between the cusps, both on the inner and outer sides of the crown. The outer cusps are more prominent than the inner ones, and this feature is most marked on the anterior tooth and least on the posterior one. The anterior tooth has evidently had the usual six cusps, but the greater part of the anterior inner one is wanting. The anterior and outer cusp is somewhat larger than either of the others (or those on the other teeth), and this causes an outward projection of the front of the crown unlike what is seen in the living Hamster. The second tooth has four cusps approximately equal in size, and the third tooth has four cusps, the hindermost pair of which are markedly smaller than the others, and consequently this tooth is reduced in width posteriorly. The inner cusps are all a little in advance of the outer ones, so that on the worn surface they seem to

[1] W. A. Sanford, Quart. Journ. Geol. Soc., 1870, vol. xxvi, p. 128, and Proc. Somersets. Nat. Hist. Soc., 1870, vol. xv, p. 56.

form oblique transverse ridges, which are, however, interrupted in the middle by a deep depression, which is in part due to wearing away by the attrition of the lower grinders, and which runs from front to back along the middle of the three teeth. The anterior molar has a distinct cingulum running along the inner side of the crown, and a similar cingulum, but much less distinct, is also to be seen on the second and third molars.

Cricetus vulgaris Runtonensis, n.subsp. From the Norfolk Forest Bed at West Runton. Grinding surfaces of three molars of right maxilla, enlarged six times. The specimen is in the possession of A. C. Savin, Esq., of Cromer.

A comparison of this little maxilla with a number of recent specimens in the British Museum at South Kensington and in the Museum of the Royal College of Surgeons, Lincolns Inn Fields,[1] leaves no doubt as to its generic identity with the common Hamster *Cricetus vulgaris* (= *frumentarius*). The main characters of the teeth are the same; but in none of the recent specimens is the anterior outer cusp of the first molar larger than the others, and there is no outward expansion of this region which would correspond with a larger anterior cusp. The teeth of the 'Forest Bed' specimen are likewise larger than those of any of the recent specimens examined, in which the length of the series of three upper crowns varied from 7·4 to 7·7 mm. Dr. Nehring[2] in his paper on Pleistocene Hamsters gives the extreme measurements of the three upper teeth in recent Hamsters as 7·4 and 8·0 mm.

The large size and difference in structure of these 'Forest Bed' teeth, as well as the age of the beds from which our fossil was obtained, make it highly probable that it represents a form specifically distinct

[1] I am pleased to have this opportunity of thanking the officers in charge at both these institutions for the courteous assistance so kindly rendered on this as on many other occasions.

[2] "Ueber pleistocäne Hamster-Reste aus Mittel- und Westeuropa": Jahrb. k.k. geol. Reichsanst., 1893, Band xliii, Heft ii, p. 179.

from the living *Cricetus vulgaris*. M. C. Depéret[1] has described two lower jaw rami of a *Cricetus* from the Pliocene of Perpignan under the name of *Cricetus angustidens*.[2] These are said to agree as nearly as possible with the living *C. vulgaris*, but the species is distinguished by the narrowness of the anterior molar tooth and by the obliquity of the tubercles, which are compressed and directed forwards so as to join the external tubercle of the pair next in front; also the two anterior tubercles are small. It is obvious that the structure of these teeth is unlike what obtains in the 'Forest Bed' specimen.

Dr. Nehring,[3] in the paper above referred to, discusses the affinities of the larger and smaller species of *Cricetus* found in the Pleistocene deposits of various localities in Middle and Western Europe, and draws special attention to the large jaws described and named by Dr. Woldřich[4] *Cricetus frumentarius major*. These large specimens seem to agree very closely in size with our 'Forest Bed' form, but the series of upper grinders are not quite so large. Dr. Woldřich gives the alveolar measurements of his two largest specimens as 8·8 and 9·5 mm. The same measurement of the 'Forest Bed' specimen is 10·3 mm. The description of these large Hamsters is not sufficiently detailed to allow of a close comparison with the peculiarities observed in the 'Forest Bed' example, and the figures of the teeth are not large enough to give the smaller details of structure; it seems, however, from Dr. Woldřich's figure (loc. cit., pl. ii, fig. 23), that the anterior tubercles of the front tooth are somewhat narrower than the others.

Dr. Nehring (loc. cit., p. 185) seems to think Dr. Woldřich hardly justified in giving the subspecific title *C. frumentarius major* to these fossil forms, as he says there is much variation in size among living Hamsters: but, according to Dr. Nehring's own measurements, no recent Hamster has attained to the size of Dr. Woldřich's fossils, and Dr. Nehring himself includes them under his own subspecies *C. vulgaris fossilis*. If a third name is to be used, that of Dr. Woldřich should be adopted.

During the last few years several living forms of *Cricetus* have been described and provided with subspecific or race names, but for the most part these are distinguished by external characters, and make no nearer approach to our fossil than does the common Hamster itself. I am not aware that any fossil Hamsters have been described other than those already alluded to; but there are two or three papers [5, 6, 7]

[1] "Les Animaux pliocènes du Roussillon": Mém. Soc. Géol. France, 1890, vol. i, Mém. No. 3, p. 54.

[2] See also Dr. Woldřich, "Uebersicht der Wirbelthierefauna des Böhmischen Massivs während der anthropozoischen Epoche": Jahrb. k.k. geol. Reichsanst., 1897, Band xlvii, p. 393.

[3] See note 2, p. 111.

[4] "Diluviale Fauna von Zuzlawitz bei Winterberg im Böhmerwalde": Sitzb. d. k. Akad. d. Wiss. in Wien, 1880, Band lxxxii, p. 30.

[5] J. Kafka, "Recente und Fossile Nagethiere Böhems": Arch. Landesdf. Böhem, 1893, vol. viii, No. 5.

[6] J. Nüesch, "Das Schweizersbild, eine Niederlassung aus paläolithischer und neolithischer Zeit": Denkschr. schweiz. Gesellsch. Naturw., 1896, Band xxxv, pp. 1–334.

[7] Dr. A. Nehring, "Ueber die pleistocäne Fauna der Belgischen Hölen": Sitz. Gesellsch. Naturf. Freunde, Berlin, 1897, p. 74.

on fossil rodents, including the genus *Cricetus*, to which reference may profitably be made, that by H. J. Nüesch having an account of the small mammals by Dr. A. Nehring.

If the 'Forest Bed' specimen were of the same age as those described by Dr. Woldřich, one would have had little hesitation in referring them provisionally to the same subspecies; but the evidence in favour of these Norfolk deposits being of Pliocene age is becoming stronger. Dr. Forsyth Major's[1] study of the Forest Bed Voles has led him to think that most of the 'Forest Bed' mammals now referred to living species will eventually prove to be extinct forms, and recent investigations seem to lend strength to his opinions.

A name is needed by which this unique Hamster from the 'Forest Bed' may be known, and under the circumstances it would scarcely be wise to adopt the name of a Pleistocene form, as this would seem to imply affinities for which we have no grounds. It is very unlikely that additional evidence will be obtained for a long time to come, and I suggest that we regard this fossil as representing a peculiar race and call it *Cricetus vulgaris Runtonensis*.

V.—On the Geologic Conditions affecting the Coasts of England and Wales, with special reference to the Coast-line from Lynn to Wells (Norfolk) and from Yarmouth to Eastbourne (Suffolk, Essex, Kent, and Sussex).

By W. Whitaker, B.A., F.R.S.

(*Concluded from the February Number*, p. 56.)

HAVING now given a short account of the geology of the long line of coast from Yarmouth to Eastbourne, one may say of the first part of it, north of the Thames, that it is, so to speak, most favourably constructed for coast-erosion. Without a single hard or firm rock, such as the Chalk; without anything that can form a nearly perpendicular cliff of any height, no cliff indeed being high enough to give rise to a respectable landslip; composed of loose sand and gravels, loams and clays (the last partly strengthened by thin layers of soft stone), there is really nothing to withstand either the assaults of atmospheric action from above or of the sea below. Such parts as are of special interest or have been subject to special observation will now be noticed.

Along this coast the general movement of the shingle is southward, or toward the Thames. Owing to this the most easterly point of this island, Lowestoft Ness, consists of low flat land gained from the sea, a tract of Blown Sand and Shingle about 2½ miles long and nowhere half a mile broad. The seaward extension of the harbour has helped to arrest the progress of the shingle and to pile it up on the northern side. Naturally this has led to a decrease of shingle on the other side of the harbour, and on my last visit, in 1902, the defences of the southern part of the town, by Pakefield, had been overcome and the cliff cut back so as to endanger some of the houses. [Since the above was written further loss of land has taken place here.] Curiously enough, however, at Kessingland, the southern end of this long line of

[1] "The Mammalian Fauna of the Forest Bed": Geol. Mag., 1908, p. 329.

cliff, a little Blown Sand had accumulated at the foot and had been artificially helped to form a protection, so that here erosion was checked, whereas when I was first there, many years ago, it was going on markedly. At Covehithe I have measured the greatest loss of land that has come under my notice, namely, about 60 feet in a year. In nine years (1878–87) the loss was at the rate of something over 18 feet a year.

Easton Bavent (a place now gone) is also a case of continuous marked loss, and I was able to take measurements from 1878 to 1882. Others taken before and since are noticed in the Geological Survey Memoir on the district (1887). At a later visit, however, I found a change in the course of things; what had been a fairly clear cliff, showing a long and good section of shelly Crag below gravel, had changed to a weathered-down slope, with no sign of the Crag except where rabbits had obligingly made holes at one part. Erosion therefore had been checked here. On the other hand, whilst I was living at Southwold (1878, etc.) there was practically no change there, but since then erosion has occurred to a considerable extent, and has been duly recorded by Mr. Spiller.[1]

At Dunwich again, one of the most noted places in the matter of coast-loss, there was practically no change while I was first in that neighbourhood, and apparently there had been very little for some years, there being a good deal of talus at the base of the cliff, so that none of the shelly Crag was to be seen. Up to 1897, indeed, there were but two or three geologists who had seen that bed in the southern part of this cliff, and they had seen but little of it. But then the base of the cliffs having been swept bare, good sections of shelly Crag were seen by many observers (including myself) in 1898, and the cliffs were again cut back. From Easton Bavent to Dunwich, therefore, in the course of less than thirty years there has been a good deal of vacillation in the process of erosion.

The growth of the shingle-spit southward from Aldeburgh is remarkable. The Alde must have once flowed direct to the sea just south of that town, whereas now it has been doubled back south-westward for several miles, not joining the sea until past Hollesley. Some day perhaps the river may be able to force a passage through a narrow part of the shingle, either by Aldeburgh or by Havergate Island. This sort of thing has happened in the past, as also, to my knowledge, near Christchurch, in Hants.

Some miles further on the shorter shingle-spit of Landguard Common seems to have slightly deflected the combined channel of the Orwell and Stour. The shingle can hardly cross this broad and fairly deep water, and the London Clay cliff of Dovercourt has, therefore, little protection from the sea, the foreshore consisting of that clay, with layers of cement-stone. These stones make a sort of pavement where they have not been removed, as they once were, for the manufacture of Roman cement; that removal probably facilitated the cutting back of the cliff.

At the Naze slips occur, water being thrown out at the junction of

[1] Geol. Mag., 1896, pp. 23–27.

the Crag (shelly sand) with the London Clay. Here and along the stretch of London Clay cliffs to Clacton there is no great protection of the base of the cliff by beach, and the foreshore consists largely of the clay.

The marshes that form the coast of southern Essex are protected by earthern sea-walls and are areas of accretion rather than of destruction. In the midst of these marshes there are small tracts of shingle, the long broken line in the marshes between the Blackwater and the Crouch pointing to a former shore-line, of which the smaller patches of shingle in Foulness may be an extension.

Crossing the Thames the general movement of the shingle is in a reverse direction to what we have hitherto had, that is to say, westward and northward, but still toward the Thames. The cliffs of Sheppey are a noted instance of continuous loss of land, Warden Church and churchyard having gone in late years. The clay coast of the mainland eastward also wastes steadily, and at the highest cliffs, east of Herne Bay, there are often good examples of what are not inaptly termed mud-glaciers, streams of moist broken-up clay that flow down the slopes and are crevassed as ice-flows are. At Reculvers the Roman station has been destroyed to the extent of a half, and it is only by careful protective work that the twin towers of the old church within the walls have been kept.

The Chalk of the Isle of Thanet forms a huge natural breakwater, without which there would have been great destruction of the softer Tertiary beds to the west and south. This tract is a good example of the effect of joint-planes on the erosion of cliffs. There is a dominant set of these planes, roughly from N.W. to S.E., and these have led to the cutting out of projecting masses and sometimes of isolated stacks. The line of cliff from Foreness to White Ness, at the north-eastern part, is cut along such joint-planes. In the neighbourhood of Ramsgate sets of small faults, some too small to be shown on the map, have a marked effect.

On reaching the marshes of the Stour we find a point of some interest in regard to changes in coastal conditions. In Kent, as has been said above, the general movement of the shingle is toward the Thames, which in this case means northward from Deal toward Thanet. In accordance with this the shingle of the coast and its accompanying Blown Sand form a ridge with a northerly extension, ending at the Stour; but a little way in from the shore of Thanet we have evidence that once it was otherwise. We have there a short shingle-bank running from the higher land at Cliffs End over the marshes south-westward, and then another and longer bank from the rising land at Half Way House southward across the marshes to Stonar, where it ends in a broader mass. These shingle-banks, which show old shores, must have been formed from the north to the south, or in the reverse direction to the later shingle of the present coast.

Here, too, we have another good example of the deflection of a river by the gradual lengthening of a beach. The Stour must once have flowed direct to the sea; but by the extension of the old beach it has been driven down southward to Sandwich, when it returns northward (getting close to its course on the other side of the beach at Stonar

Cut) and then, after some 6 miles of wandering, again takes its regular easterly route to the sea.

Northward from Deal there has been considerable loss of land from the travelling of the shingle northward. When I was a boy Sandown Castle (dating from Henry VIII) was in sound condition and inhabited: now it has been destroyed, and the batteries farther north have shared a like fate. Deal itself is protected by groynes, and the stopping of the shingle here has probably aided in the destruction of Sandown. From Deal southward the breadth of the shingle has increased much since the time of the old Ordnance map (Sheet 3, published 1819). [This increase was duly noted on the Geological Survey Map years ago, as well as other changes of a like sort.]

There are sometimes large falls at places along the Chalk coast, but the loss here is not to be compared to that of the coasts of Norfolk, Suffolk, and Essex. The former extension of the land is well shown, as in other like coasts, by the cutting back of dry valleys and combes, the bottoms of which are sometimes at a considerable height above the shore.

The Admiralty Pier at Dover has caused a small accumulation of shingle on its western side, and has probably hindered the passage of shingle along the coast north-eastward, thus leaving the base of the cliffs unprotected and aiding their erosion. The great extension of the harbour-works here will probably increase this aid.

West of Abbotscliff we come to the Undercliff (a good example of coastal landslip), due partly perhaps to the clayey character of the Chalk Marl at the base of the formation, but still more to the underlying Gault clay, which forms a damp slippery yielding bed to the Chalk above. The Gault itself, in East Wear Bay, is of course readily eroded. [At Sandgate landslips have occurred through the clayey Sandgate Beds holding up the water in the overlying permeable Folkestone Beds, and forming a good slide.]

The great alluvial flat of Romney Marsh, below high water of spring-tides, is an area of deposit, and is protected either artificially by sea-walls or naturally by great spreads or banks of shingle. The gradual growth of this latter and its extension outward, from the west to Dungeness, is well shown on the Geological Survey Map (Sheet 4).

The way in which many of the successive fulls of Dunge Beach tail off inland into narrow strips, divided by Alluvium, is notable, and at the heads of the little valleys thus formed there are often small springs or outflows of fresh water. The bare shingle probably absorbs rain more quickly and in greater quantity than any other gathering ground in the kingdom, so that some way inland from the shore there is no room for infiltration of sea-water.

The bay marked on the old map eastward of New Romney is now filled up. An old shore-line seems to be shown by the shingle on which that town stands and by that of Lydd.

At Fairlight the broken cliffs consist of permeable sand above, with clay beneath, and the result is a considerable landslip, which ceases westward where the clays do not come to the surface, the massive sand, about 150 feet thick, then forming a nearly vertical cliff with clay above at the higher parts, which therefore give way.

At and beyond Hastings the coast is more or less protected, and the Pevensey Levels, like Romney Marsh, have either sea-wall or shingle-bank to keep the sea from the marshes.

To give details of the amount of waste of land along those parts of the coast treated of would involve much work of compilation: the facts are to be found in Geological Survey Memoirs, in British Association Reports, and in other publications, which are duly noted in the Bibliographic List in the Report of the Royal Commission.

In the above notes I have simply tried to give information as to the various coastal conditions, with a general account of what is happening or has happened of late years.

General Conclusions.

As regards what can be done to decrease the waste of land along our coasts, it is clear that this must vary greatly in various places. I do not speak of *stopping* that waste, as I believe this to be impossible. The actions of atmospheric weathering are always going on everywhere, especially perhaps along a coast, where a free margin is provided for the loss of wasted material: we cannot stop them, though we may greatly delay their proceedings. There are two things, however, that surely could be done quickly and could not fail to have effect in many places.

Nature has so generally put a limit to her work by the piling up of shingle: surely it should be an easy matter to prevent the taking away of that shingle, taken as it is for the small gain of comparatively few persons at the great loss of many.

A stop should be put to the taking away of shingle from protective beaches, that is, in the great majority of places. There may be tracts where the taking of shingle is practically harmless, as in the inland reaches. For instance, one cannot see how the loss of some of the shingle of Dungeness can in any way affect the coast, of course on the understanding that nothing is touched within some distance of the shore. At the same time there remains the question whether, in some future change in the action of coastal eroding forces, these inland masses may not be attacked by the sea and their material shifted on elsewhere, in which case, of course, the stronger they are the better their power of resistance.

The second point is also a very simple one. It is inadvisable that land should be ploughed up almost to the edge of cliffs, as is often the case. By keeping a broad border of unbroken ground, under grass or other growth, along a coast, the destructive atmospheric actions may be checked, whereas on ploughed land there is every facility for rain to sink through and for cracks to occur. On poor porous land there can be practically no loss in giving up such a strip.

Another matter is the prevention of small isolated attempts at protection, often badly planned and badly carried out, and which commonly result in little else than waste of money, and now and then in damage to neighbouring land. It is pitiful sometimes to see these feeble, useless efforts, with their waste of work. Owners of land along the coast and those otherwise interested in checking coastal waste should be led to understand that useful protective work can

only be rightly done on a comparatively large scale, with a large amount of combination between landowners, local authorities, and perhaps some more central body. I do not see, however, that the last point can be pushed to what may seem its logical end, that is, universal protection, for reasons now to be given.

In the first place, the land of much of our sea-bord is of little value, as land; often, indeed, the cost of effective protection would be many times that value. In such a case, of course, it would be a losing game to make such protective works as would be needed, unless by so doing the protection of some far more valuable or important parts in the neighbourhood could be aided by the protection of the comparatively valueless land, as far as is possible. On the other hand, it is equally possible that the protection of the less important part might add to the difficulty of dealing with the more important. It is not always that a coast-town can do all the work needed for its security within its own boundary, neither has such a town power to stop or to control work, beyond its boundary, that may be harmful.

Again, were protection practically universal, if it could be for a time, what would happen? Clearly no fresh material for the formation of beach would be brought to the shore from the cliffs, and there would be nothing to replace wear and tear of the constantly moving beach. Moreover, the steady movement of beach along the shore, in given directions, would result in its being swept away from certain parts, which would then be left in a state more fully open to the action of the sea, so that their defences might be overstrained and broken, when rapid erosion would probably set in.

As regards those parts of the coast which are composed of hard rocks, generally speaking, protection is needless, and moreover would often be impossible. Sometimes there is little or no shore, the cliffs being in places reached by the sea at all states of the tide, or nearly so; so that protective works could hardly be made. Moreover, it is from the comparatively slight waste of the cliffs of hard rock that some material is provided for the natural protection, by beach, of other and more attackable parts of the coast.

I think, therefore, that in the first place efforts should be directed to the protection of the more important parts of the coast, such as where there are towns and villages. The towns, of course, have done much work in this way and often with great success; but it seems to have become essential to extend the work far beyond their boundaries, and the spirit of parochialism should be exorcised in this matter. Harbours and the mouths of rivers naturally fall into this class.

There are parts of the coast where, as a rule, little interference is needed, that is, in the large low alluvial tracts. In such cases as the Wash it has paid in the past to do large works of enclosure (so as to reclaim land) and to make seaward defences for that land. Presumably, therefore, it will pay in the future to keep those defences in order, and in some cases also to extend the work of reclamation. Land so gained is of value and can pay for itself; but here, too, there may be need of concerted action. Well thought out large schemes will be better and cheaper than patchwork.

In the original Report (Appendices, pp. 146–158) this Memorandum is followed by a "Chronological List of Works relating to Coast-erosion, Coast-accretion, and Coast-deposits of England and Wales", dating from 1675 to 1907. A few further entries may be made in a later Report.

The Appendix by Mr. Reid, already referred to, is followed by Appendices by Professor Lebour and Mr. R. H. Worth (Northumberland, Durham, and South Devon, pp. 175–184), a map of the Wash by Mr. W. H. Wheeler, and a statement by Mr. T. M. Reade (Rhyl to Gosforth, pp. 209–211).

VI.—Notes on a Well-sinking in the Great Oolite of Lansdown, Bath.

By the Rev. H. H. Winwood, M.A., F.G.S.

THE following particulars were obtained with the assistance of Mr. Isaac Sumsion, jun., Hon. Sec. of the Golf Club:—

Section of Well in Great Oolite at the Lansdown Golf Club, north of the Blathwait Arms, Lansdown, on the 750 ft. Contour, 1908.

		Thickness.			Depth.	
		ft.	in.		ft.	in.
	Turf and mould	1	0	...	1	0
Great Oolite.	Brown, fissile, shelly, oolitic limestones, coarse and crystalline; the organic remains very fragmentary	6	6	...	7	6
	Yellow, more solid beds of oolite, lighter in colour than beds above and finer in grain	7	6	...	15	0
	Very fossiliferous bed, one portion composed entirely of well-preserved shells of *Rhynchonella concinna*, *R. obsoleta*, and *Terebratula*	0	5	...	15	5
	Close-grained tough beds of finer oolite, in part crystalline. So-called 'Bastard Oolite', used for walling	4	1	...	19	6
	Thin seam of yellow clay	0	0	...	0	0
	Blue limestone, non-oolitic	0	8	...	20	2
	Blue clay	1	0	...	21	2
	Yellow clay	0	1½	...	21	3½
	Yellow, compact, oolitic rock	1	6	...	22	9½
	Thick yellow oolite	1	0	...	23	9½
	Yellow clay parting	—		...	—	
	Thick, yellow, drusy, oolitic limestone	0	9	...	24	6½
	Coarse-grained, tough, yellow, oolitic limestone	5	9	...	30	3½
	Thin oolitic band, moist	0	1	...	30	4½
	Yellow clay	—		...	—	
	Blue limestone, banded with yellow	0	9	...	31	1½
	Blue clay	0	6	...	31	7½
	Blue limestone, partially oolitic	1	0½	...	32	8
Fuller's Earth.	Light-blue greasy clay, with hard, fossiliferous, shaly, limestone bands, fossil wood, and 'cone-in-cone'; Ostracoda, *Cythere oscillum*, *C. sphærulata*, *Cytheridea Bradiana*, etc., and some Lamellibranchs	25	4	...	58	0

Mr. Sumsion states that there is a good supply of water, and the result of the examination by the City Analyst shows it to be of excellent quality—

Chlorine as chlorides	·84 grain per gallon
Free ammonia	none
Albuminoid ammonia	·0014 grain per gallon
Total solids	16 grains ,,
Oxygen required to oxydize decomposing matter	none
Nitric acid as nitrates	none

The water was perfectly clear and without sediment.

Mr. L. Richardson, who kindly examined the fossils from the Fuller's Earth, informs me that "the hard grey shale from a depth of 36 ft. 6 in. contains an *Ostrea* of the *O. Sowerbyi*-type; and that from a depth of 54 ft. contains numerous specimens of *Trigonia clapensis*, Terquem & Gourdy, and a *Placunopsis* near to *P. sociale*, M. & L. There were also present internal casts of *Pleuromya*, *Placunopsis detrita* (Terq. & Gourdy), *Tancredia*? *brevis*, M. & L., *Leda lachryma* (Sow.), and Ostracods".

The Great Oolite, which is nearly 33 feet thick, represents only the lower portion of the formation, or the "Lower Rag beds", which occur beneath the main freestones of Box and Corsham. The Lower Rags are seldom exposed, but we have records of 15 to 20 feet at Odd Down, 17 to 40 feet at Box, 45 feet at Corsham, and 43 feet at Murrel, near Winsley.[1] The beds evidently vary a good deal in detail within short distances, and the freestones occur on somewhat different horizons in the series above the Lower Rags.

The Rev. Joseph Townsend, in 1813, remarked that "Lansdown has the bottom beds, which terminate on the Northern hanging of the hill, and it is curious to observe numerous pits remaining near the monument, to remind us of the ignorance which prevailed in former times; because from these very pits, at the distance of four miles from Bath, all the free-stone was taken for building the city and cathedral [Abbey], although the same kind of stone was immediately at hand, but concealed, till Mr. Allen opened his quarries behind Prior Park".[2] This probably is not quite correct, as the view now generally accepted is that the stone for the Abbey came from a disused quarry near Entry Hill, on the south side of Bath, and that the old pits on Lansdown were opened to obtain flaggy beds mainly for roofing purposes.

VII.—Note on the Shore Sand of St. Ives Bay, Cornwall.

By T. Crook, F.G.S., & G. M. Davies.

THE shore and dune sand of St. Ives Bay is typically light coloured owing to the predominance of calcareous matter in the form of shell fragments, etc. But the actual proportion of the platy shell

[1] See Lonsdale, Trans. Geol. Soc., ser. II, vol. iii, p. 253; H. B. Woodward, "The Jurassic Rocks of Britain," Mem. Geol. Surv., vol. iv, pp. 261–7; and H. H. Winwood, Proc. Geol. Assoc., 1896, vol. xiv, p. 347.

[2] "The Character of Moses," 4to, Bath, p. 150; see also p. 192.

fragments to the heavier and more granular ingredients of the sand varies considerably, especially within the limits of high- and low-water marks, as is usually the case. Some of the heavier ingredients are dark-coloured, and may be observed to have been streaked out in bands or aggregated in patches at the surface, where they have been concentrated by the action of the waves. Where heavy minerals abound, tidal action can be seen to have effected a persistent concentration about the mean high-water mark, where the heavier ingredients predominate for at least a foot beneath the surface. Such a band can be easily traced for a considerable distance in the vicinity of the Red River.

A specimen collected from this band at a point about midway between Red River and Hayle River was found to contain about 30 per cent. of shelly matter, etc. The residue left after dissolving this calcareous portion of the sand in cold, weak acid was found to have approximately the following mineral composition:—

			Per cent.	
Strongly magnetic	Magnetic iron oxide		1	
Weakly magnetic	Killas fragments		74	Dark-coloured portion.
	Tourmaline			
	Impure quartz			
	Brown biotite			
	Chlorite			
	Siderite			
Non-magnetic	Quartz	s.g. < 2·84 (bromoform)	10	Light-coloured portion.
	Felspar			
	Killas fragments			
	Fluorspar	s.g. > 2·84 < 3·32		
	Andalusite			
	Topaz		15 (almost wholly fluorspar)	
	Free tinstone	s.g. > 3·32 (methylene iodide)		
	Killas fragments impregnated with tinstone			
	Zircon			
	Spinel			

The constituent referred to as magnetic iron oxide is complex. It appears to be partially hydrated, and probably consists of a mixture of magnetite, hæmatite, and hydrated iron oxide, the magnetite predominating. With the exception of a slight amount of hæmatite, it is opaque even in the smallest particles. It is apparently non-titaniferous.

The killas fragments show a very compact structure; they are for the most part weakly magnetic, owing to the presence of magnetic enclosures, many of which are black, and consist, in part at least, of magnetic iron oxide. The non-magnetic killas fragments are either free from dark enclosures or are impregnated with granules of tinstone; in the former case they float in bromoform, in the latter they may sink even in methylene iodide.

The tourmalines are chiefly brown; but some are blue, while others are almost colourless in ordinary light.

The impure and weakly magnetic quartz is in part rusty and in part impregnated with fine needles of tourmaline. The non-magnetic quartz is very dusty in appearance, due to the abundance of liquid inclusions, with numerous gas bubbles.

The non-magnetic portion heavier than bromoform consists almost wholly of fluorspar, with only small amounts of the other constituents, including andalusite, topaz, killas fragments impregnated with tinstone granules, and a few small free grains of tinstone.

The fluorspar fragments are mainly colourless, but many of them show a well-marked violet colour. They are isotropic. They exhibit the characteristic octahedral cleavage, yielding numerous triangular plates with bevelled edges. Their very low refractive index is a striking feature.

The andalusite fragments are partly irregular in shape, but some of them are elongated prisms, with definite limiting edges; these latter show straight extinction. They have a refractive index about 1·64, and are optically negative. They exhibit the characteristic pleochroism, showing the rose tint when the short diagonal of the polarizer is along the length.

The topaz fragments are partly granular and partly in the form of good basal cleavage plates. These latter show the normal emergence of the acute bisectrix, which is positive; and they also show the feeble birefringence characteristic of basal flakes of topaz, with a refractive index near 1·61.

Siderite in rhombohedral cleavage plates, pale spinel in irregular grains or octahedra, zircon crystals, ilmenite, epidote, muscovite, free grains of tinstone, and probably also rutile and blue corundum are seen occasionally in the sand.

A lighter-coloured sand from near low-water mark at the same locality, and another from near Lelant about half a mile to the west of Hayle River, both contained about 70 per cent. of shell fragments, etc. Their insoluble residues contained the same ingredients as the specimen already described, but in different proportions; and the heavier minerals were present only in small amounts.

It seems, therefore, that fluorspar, andalusite, topaz, and tinstone are probably distributed throughout the sands of St. Ives Bay. The amount of fluorspar is considerable, that of andalusite and topaz small, whereas the amount of tinstone is very small, the mineral being mostly present as fine granules disseminated in killas fragments. The presence of these minerals is not surprising, considering their abundance in the granite and killas of Cornwall; but it is perhaps rather remarkable that one can pick up sands so rich in fluorspar.

There can be little doubt that the non-calcareous portion of these sands consists chiefly of the products of mining activity brought down to the coast by the Red River. It appears to be practically identical in its general character with the Red River sand described by the officers of the Geological Survey (see Memoirs, "Geology of Falmouth and Camborne," 1906, p. 273). The total amount of stamp-battery products and other mining refuse brought down by the

Red River to the coast must have been enormous, and has obviously contributed to the building up of the aggressive dune sands of this district.

The mineral composition of the sand of St. Ives Bay thus affords a good example of the influence of the human factor in geological processes.

VIII.—On the Chalk Section at the Waterworks Quarry, Marlow.

By Charles P. Chatwin & Thomas H. Withers.

HAVING had occasion to work at the Chalk Rock in this quarry, we took advantage of the opportunity to examine the whole of the Chalk exposed above that bed, which, owing to the inaccessibility of the upper half of the quarry, had not been examined in detail. The floor of the quarry coincides in part with the top of the Chalk Rock, and as there is a vertical face of nearly 50 feet of Chalk above it, the junction of the zones of *Holaster planus* and *Micraster cor-testudinarium* was to be expected in the upper portion of the section, and it was with the object of defining the junction of these two zones that we paid attention to the higher beds.

It was found possible, with the aid of a ladder, to collect from the upper half of the quarry and to determine the zonal junction, and owing to the interest attached to the finding of the Ammonite described in the preceding paper (see February Number, p. 66), this seems a fitting opportunity to give a complete description of the section. The first description was given in the Survey Memoir,[1] in which the Chalk was assigned to the lower part of the *Micraster cor-testudinarium* zone. In a later publication [2] the beds were described as belonging to the upper part of the same zone. Later, Messrs. L. Treacher & H. J. Osborne White [3] correctly referred the lower part of the quarry to the zone of *Holaster planus*, and the higher beds to that of *Micraster cor-testudinarium*, but were unable to obtain sufficient evidence to fix the junction of the two zones. They further state that the floor in part coincides with the top of the Chalk Rock, but record no fossils from that bed. A long stretch of Chalk is exposed in the quarry, and it is probable that the descriptions by the Geological Survey were based on the Chalk at the south-western end, which is now railed off and has not been worked for some considerable time. The beds dip to the south-west, thus allowing slightly higher Chalk to come in at that end of the section, and this would account for some difference in the horizons given. The present description is based on the vertical section seen a few yards to the right of the railings which divide the old from the new working.

To the north-east of the pit the floor is formed by the Chalk Rock, which is grass-covered; consequently the soil has to be removed to obtain an exposure. Several fossils representative of the *Reussianum*-zone fauna were obtained from this bed, as well as the two fragments

[1] "Geology of London": Mem. Geol. Surv., 1889, vol. i, p. 76.
[2] "Cretaceous Rocks of Britain": ibid., 1904, vol. iii, p. 217.
[3] "Excursion to Marlow": Proc. Geol. Assoc., 1905, vol. xix, pp. 157–8.

of *Puzosia* described,[1] which were found in the weathered rock immediately beneath the soil. About 10 feet above the level of the Chalk Rock there is a prominent band of tabular flint which shows step-faulting, the total downthrow being 2 feet to the north-east. There are no well-marked lithological features above the tabular flint band, so that either this band or the Chalk Rock can be used as a datum-line. The interporiferous areas of the examples of *Micraster præcursor* collected below the tabular band vary from sutured to feebly inflated. Those from this point up to 4 feet above the tabular band, have feebly to moderately inflated 'areas' and belong to the upper *Holaster planus*-zone type. Above this horizon the 'areas' of the Micrasters gradually become more strongly inflated, and not until the height of 16 feet above the tabular band do they exhibit the features of the *Micraster cor-testudinarium*-zone type. At this horizon occurs a band of nodular flints, and this may be regarded as marking the junction between the two zones. The thickness of the *Holaster planus* zone, if we estimate the thickness of the Chalk Rock at 6 feet, is therefore 32 feet.

The following is the section seen, with the fossils collected from the various beds:—

		Feet.
Micraster cor-testudinarium zone.	Firm white chalk with many bands of nodular and tabular flint	23
	Micraster præcursor, *Cardiaster cotteauanus*.	
	Greyish, lumpy chalk with tabular flint lines and small scattered flints. One conspicuous band occurs about 10 feet from the floor	26
	Micraster præcursor, *M. cor-testudinarium*, *Echinocorys scutatus*, var. *gibbus*, *Holaster placenta*, *Cidaris serrifera*, *Dimyodon nilssoni*, *Inoceramus* sp., *Ostrea* sp., *Spondylus latus*, *S. spinosus*, *Crania ignabergensis*, *Rhynchonella recdensis*, *Terebratula carnea*, *T. semiglobosa*, *Serpula ampullacea*, *S. fluctuata*, *S. plana*, *Terebella lewesiensis*, *Coscinopora* sp.	
Holaster planus zone.	Floor of pit.	
	Chalk Rock. Massive cream-coloured limestone, with layers of green-coated nodules . . . seen for	3
	Micraster leskei, *M. præcursor*, *Inoceramus* sp., *Area* (*Barbatia*) sp., cf. *geinitzi*, ? *Solariella gemmata*, *Trochus schlüteri*, *Turbo geinitzi*, *Nautilus* sp., *Scaphites geinitzi*, *Pachydiscus peramplus*, *Puzosia curvatisulcata*, sp. nov., *Terebratula semiglobosa*, ? *Parasmilia granulata*, *P.* aff. *serpentina*.	

In a previous paper[2] we commented on the connection between the thickness of the zone of *Holaster planus* and the development of the rock bed at its upper limit, and stated that where this rock bed was developed the thickness of the zone was considerably decreased. It is interesting to note that the present section confirms our views on this point. A comparison between three sections in the zone of *Holaster planus* in this part of the country will make our point clear.

[1] See GEOL. MAG., February, 1909, pp. 66–9, Pl. II.

[2] "The Zones of the Chalk in the Thames Valley between Goring and Shiplake": Proc. Geol. Assoc., 1908, vol. xx, pp. 112–13.

In the section at Aston Rowant,[1] Oxon, a compact yellowish limestone band 1 foot in thickness marks the upper limit of the zone, and here we measured 19 feet for the thickness of the zone. At Hart's Lock Wood,[2] near Whitchurch, Oxon, a band of yellowish lumpy and nodular chalk (hard and soft mixed), much less compact than at Aston Rowant, is developed at the top of the zone, but this to a thickness of 3 feet, and at this place the thickness of the zone is 24 feet. In the present section, where there is no definite rock development at the top of the zone, the thickness, as already stated, is 32 feet. We can therefore surmise that the development of a hard rock band at this horizon indicates a period of arrested or diminished sedimentation, and in connection with this it is interesting to note that in this section, where no rock bed is present, the transition between the upper *Holaster planus*-zone type of Micraster with moderately inflated 'areas' to the definite *M. cortestudinarium*-zone type with strongly inflated 'areas' occupies a more extensive vertical range.

NOTICES OF MEMOIRS.

I.—Geological Cycles in the Maritime Provinces of Canada. By G. F. Matthew, D.Sc., LL.D. Trans. Roy. Soc. Canada, 1908–9, ser. III, sect. iv, vol. ii, pp. 121–43.

THE object of this paper is to show briefly the succession and age of the several formations that were accumulated in the eastern provinces of Canada, from the earliest that can be recognized to the end of the Trias (or Jura-Trias).

As the Cambrian is well represented in these provinces by a formation that contains many characteristic faunas, it forms a basis to which the older and later formations can be co-related. The writer upon this basis affirms the presence of several formations, or systems, older than the Cambrian, and indicates the physical characteristic by which they are separable from each other (there being no fossils in these earlier groups of strata by which they can be distinguished). One of these groups is the gold-bearing or Maguma series of Nova Scotia, having the enormous thickness of 5 miles of sandstones (quartzites) and slates, the chief gold-bearing zone being near the middle of the succession. Older than this is a group containing much limestone, which the author compares to the Grenville Limestones of the Laurentian system. Younger than the Maguma series, but older than the Cambrian, are other groups of strata, many of which consist largely of effusive rocks.

Above the Cambrian (which includes also the Lower Ordovician) there is a break in the succession; the Upper Ordovician is wanting, and the Upper Silurian begins in many districts with effusive rocks and elsewhere with sandstones; these are succeeded by fine dark-grey shales, and these by paler shales and sandstones, which are also more

[1] Mem. Geol. Surv. (Expl. Sheet 254), Henley-on-Thames, 1908, pp. 39, 40.
[2] Proc. Geol. Assoc., 1908, vol. xx, p. 396.

calcareous. These are seen by their faunas, as shown at Arisaig, etc., to range from the Llandovery to the Ludlow or higher. A peculiar phase of this formation is the plant-bearing beds near St. John, N.B., which contain many types of plants that reappeared in the Carboniferous, with others that are special to this locality.

Following this formation there is a break in the succession, the Middle Devonian being absent, or at least not recognized by its marine fossils, and the next formation (Upper Devonian) by its plant remains shows a close relation with the Lower Carboniferous, yet it has many typical Devonian genera and species of plants. The Carboniferous Age began with a widely extended deposit of marine limestones spreading through nearly the whole length of the eastern provinces in a belt across their centre, but not known in their northern part. The Millstone Grit and Coal-measures followed in a widely extended tract to and under the Gulf of St. Lawrence. In a northerly direction they were covered by the Permo-Carboniferous found along the borders of the gulf and extending into the province of Prince Edward's Island.

The final geological system of this part of Canada was the Trias (or Jura-Trias), which occupied a large area in the Bay of Fundy and the Basin of Mines, and is also found in the islands of the Gulf of St. Lawrence. In the Bay of Fundy area and the Basin of Mines the system is characterized by extensive eruptions of dolerite and volcanic-ash deposits that have left a strong imprint on the topography of the country as it now appears. Subsequent to the Jura-Trias there were no great geological systems laid down in this region, and it is supposed that it remained for long ages above the sea. Only in post-Pliocene time did the sea again invade these provinces, and lay down a marine fauna closely related to and mostly of species living at the present time.

II.—Brief Notices.

Fluorspar.—An important paper on "The Fluorspar Deposits of Derbyshire" has been contributed by Mr. C. B. Wedd, F.G.S., and Mr. G. Cooper Drabble to the Transactions of the Institution of Mining Engineers (1908, vol. xxxv, pp. 501, etc.). The authors give a general account of the structure of the Carboniferous Limestone area and of the associated igneous rocks. The limestone is from 1,500 to 1,700 feet thick, and forms the southern end of the Pennine anticline. The fluorspar appears to be confined to the upper 600 feet of the limestone, and is chiefly concentrated within 300 or 400 feet of the top. The upper beds of the limestone contain a good deal of chert, also secondary quartz; they are often dolomitic, are more fossiliferous than the lower strata, and contain bituminous products. Moreover, all the known sheets of igneous rock are found in the upper half of the great mass of Derbyshire Limestone. The mineral deposits occur in joints and cracks, in pockets and pipes, and in independent 'flats'. The fluorspar is remarkably free from silica; 1 per cent. is an exceptional quantity. The authors believe that local circumstances agree best with the hypothesis of deposition in fissures and to a small extent as a metasomatic replacement of the country-rock, from a heated aqueous solution containing gases and forced up from a great depth, possibly in

connection with the later phase of igneous activity. They hold that deposition, consequent on diminution of pressure and temperature, was precluded in the case of fluorspar from taking place in the lower parts of the vein-fissures, owing to the fact, pointed out to them by Dr. W. Pollard, that superheated steam decomposes calcium fluoride. The relatively low specific gravity of the mineral probably had some further influence in determining the limitation of the mineral to the upper parts of the fissures. The economic uses of fluorspar are discussed from an historic and practical point of view, and the paper concludes with a bibliography.

III.—Geological Hand-Map of the British Isles.—Mr. Edward Stanford, of 12, Long Acre, has sent us a copy of a neat colour-printed map with the above title, which he has published at the price of 6*d*. The size of the sheet on which the map is printed is about 7½ by 10 inches, and it should prove useful for handy reference in classes.

REVIEWS.

I.—Records of the Geological Survey of India: General Report for 1907. By Sir T. H. Holland, K.C.I.E., D.Sc., F.R.S., Director.[1]

THE Director observes in his introduction that there has been satisfactory progress in mineral production during 1907, and an extraordinary increase in the activity of prospectors, "mainly inspired by the phenomenal success of those who were already prepared to meet the increased demand for manganese-ore and coal." The statement of mineral concessions during the year is indeed most remarkable, and the details of the 600 licences granted fill thirty-one pages of the report. Clearly the prospectors are in an optimistic mood.

The Director in his obituary notice calls attention to the value and importance of Mr. Griesbach's work.[2]

Mineralogy.—The jadeite deposits in Upper Burma have been carefully investigated, and the recent conclusions, both as to the origin and age of this mineral, differ materially from the views formerly advanced.[3] It was known previously that the jadeite formed a light-coloured layer in the midst of a dark-green serpentine, and it was conjectured that the jadeite must have separated as a primary segregation from the magma. There seemed some difficulty in understanding how a soda-alumina silicate could have segregated from a magnesian rock, but recent observations tend to show that the jadeite occurs in a metamorphosed igneous dyke intruded into the serpentine. It is concluded that the jadeite is the result of the

[1] [This review was written by our late friend and co-editor, Mr. W. H. Hudleston, and sent to us on January 20, 1909, nine days before he passed away from his active, useful life, without any illness or suffering, happily engaged up to the last moment (see Obituary).—H. W.]

[2] See Geol. Mag. for 1907, p. 240.

[3] Geol. Mag., 1907, p. 328.

metamorphism of an albite-nepheline rock originally forming the dyke, since both these minerals are found in conjunction with the jadeite. The region is one where crystalline schists have been invaded by granite. The previous view that the serpentine-jadeite complex is of Tertiary age is also rendered improbable by the fact that these old eruptives, including the jadeite, are prominently represented among the boulders in the Tertiary conglomerate, which is worked expressly for that mineral. The amount raised in 1907 was 3,590 cwts., valued locally at £18,998, and mostly sent to China.

Palæontology.—Amongst items of general interest under this heading the discovery of inter-trappean fossils in the Cretaceous of Baluchistan may be noted. *Physa Prinsepii*, for instance, so characteristic of the fresh-water beds intercalated in the Deccan Trap, is found to occur in marine beds containing Upper Cretaceous (Maestrichtian) ammonites. These fresh-water shells must have been carried out to sea from the land on which the inter-trappean fossils were laid down, and in this way evidence is obtained fixing the age of the great Deccan Trap eruptions with greater precision than previously.

Some curious facts are recorded with reference to the so-called 'exotic blocks' of the Kumaon Himalaya, where the later Mesozoic beds are capped in places by massive limestone blocks (*Klippen*), which either appear to rest conformably on the soft Jurassic shales or else are imbedded in them. These blocks are partly of Palæozoic and partly of Mesozoic age, and their anomalous position among younger strata has given rise to a considerable amount of controversy. It is assumed that the exotic blocks of Kumaon were brought from somewhere further north in the Tibetan region at present unrecognized; and if so, they must represent the result of one of the most gigantic overthrusts known to geologists. The interest from a palæontological view lies in the fact that there is a remarkable agreement between the fossils of these 'Tibetan' masses and Alpine Carnic and Liassic fossils, whilst the facies is different from that of the beds of corresponding age in the normal sections within the area in question. Clearly, this is a palæontological puzzle by no means easy of interpretation.

The examination of the Cambrian fossils from Spiti, collected 1898–1901, leads to equally surprising results. The fauna comprises ten genera of Trilobites, five genera of Brachiopods, one genus of Pteropod, one Echinoderm, and one Zoophyte. Six horizons have been recognized in the region whence most of the fossils have been derived, and the fauna of each horizon is peculiar to it, no single species having been found in any two horizons. The only Trilobite that has been identified with a known species is *Redlichia Noetlingi*, and the presence of this Salt Range species is of interest as the only form known to be common to the two areas. The remaining Trilobites, with the exception of those found in the *Olenus*-horizon, as also the other fossils, are remarkable for their dissimilarity to either Salt Range or European types. The general conclusion is that the main mass of the beds must be referred to the Middle Cambrian, and that the palæontological affinities of the fossils in these beds are with the Rocky Mountain province of America. Once more, then, we find a palæontological puzzle in the disagreement of these Himalayan

fossils (Cambrian) with those of their nearest neighbours of approximately the same age. It is thought that the investigation of these Spiti Cambrians will have an important bearing on the classification adopted for the oldest Palæozoic systems of the Himalaya.

Economics.—Several pages are devoted to this subject under the heading of "Enquiries" and "Surveys". Manganese-ore, with the exception of gold, the only heavy metal of any importance as a product in India, attracts some attention. The chief object of the surveyors latterly has been to institute a comparison between the deposits in South India and those of the Central Provinces. In the latter area the ore-bodies as now constituted appear to be an integral part of the crystalline complex, although it is probable that they have attained their present character of clean oxides by alteration of manganese silicates. In South India, on the other hand, the ore deposits are more superficial, and appear to be residual products from the surface alteration of the "various lithological elements that constitute the Dharwar system of schists". The manganese-ores of this class occur irregularly associated with lithomarges, ochres, and wads. A comparison is then instituted between these shallow or surface ore-bodies and those of the crystalline complex. As regards these latter it is hinted that they may be found in depth to pass down into manganese silicates unsuitable for the requirements of the metallurgist.

In connection with the subject of petroleum in Burma "a survey of the Minbu Hills" may be taken as in some sense typical of the region in the neighbourhood of the oilfield. "This anticline of Miocene and Pliocene beds is one of great interest from a scientific point of view. Slightly asymmetric and sharply folded, it has been very extensively denuded and its deeper structure laid bare. There are many comparatively large faults, one of which appears to coincide with the line of mud volcanoes near the town of Minbu." The results of boring for oil in this particular district are not very encouraging.

As a further contribution to the economic geology of Burma, there is a note on the occurrence of tin-ore in the Mergui district. The only ore worked is cassiterite, and this occurs as a somewhat scarce constituent in a decomposed pegmatite rich in tourmaline and muscovite, in fact under conditions not dissimilar from those at home. The industry is a small one, the output in 1907 being valued at £11,882.

Geological Surveys.—In Central India the major portion of the area surveyed in 1907 is occupied by the Deccan Trap, and three thin beds of what appear to be fragmental volcanic ejectamenta were found intercalated with the normal basalts. The lowermost bed of the Deccan Trap occupies the flat plains for several miles before the upper beds composing the scarp make their appearance. The scarped edge of the Malwa plateau rises more than 1,000 feet in softer and harder beds of trap, some of which are columnar, and some contain the usual geodes, full of siliceous or zeolitic material.

The Northern Shan States of Burma are described with considerable detail, and a graptolite band (Pangh-sapýe) in the Upper Ordovician was found to be of considerable service in working out the

stratigraphy. The following are the European equivalents of the beds identified:—

Late Pliocene or Pleistocene.
Jurassic (exact horizon not yet known).
Rhætic.
Permo-Carboniferous.
Carboniferous and Devonian.
Silurian.
Ordovician.
? Cambrian.

"It is somewhat surprising that igneous rocks are of extremely rare occurrence over the whole of this area. The ancient rocks near Mogok (Ruby-Mines) are traversed by great bands of granite, and there are indications of volcanic conditions, consisting of rhyolites and rhyolitic tuffs, along the borders of the Ordovician land-surface; but throughout the whole sequence of Palæozoic and Mesozoic strata there are no traces whatever of volcanic activity. In late Tertiary times there was, however, a feeble manifestation of these agencies, for in one locality the silts were found to be traversed by dykes of basalt, resembling that of the sub-recent volcano of Hawshuenshan in south-west Yunnan."

Mineral Production of India during 1907.—The total value of minerals, as ascertained, was £7,071,868, being an increase of £759,047 (= 12 per cent.) over the previous year. For the first time the value of coal exceeds that of gold, but part of this increase may be due to the high prices of coal prevailing in 1907. Out of 11,147,339 tons raised, the Gondwana Coalfields account for 10,720,245 tons; the output of the Jherria Coalfield now exceeds that of Raniganj, which for so many years has been the leading producer. After coal and gold the next largest figures are shown by petroleum and manganese-ore; other heavy metals are insignificant in amount. Gems, including ruby, sapphire, and spinel, account for £98,258.

Striated Boulders in the Blaini Formation of Simla.—This is a special contribution by the Director to an interesting and much debated question. The writer alludes to the early notices of the so-called 'conglomerate', an inappropriate term, since the "fine-grained slaty matrix in which the boulders lie is often in excess of the volume of the pebbles". These have usually been regarded as of glacial origin, and at length a boulder (represented on plate I of the report) has been found "which shows the essential signs of glaciation to an unmistakable degree". It should be observed that there are two distinct boulder-beds separated by about 200 feet of thin-bedded shales, and the boulders under notice were obtained from the lower bed at Simla.

The story of the Talchir boulder-bed in Orissa, and its correlation with beds at the base of the Karroo system in South Africa and the coal-bearing beds of New South Wales, is well known. It gradually came to be assumed that the two boulder-beds in the Blaini formation were also of Upper Palæozoic age and equivalent to the Talchir

boulder-bed. Furthermore, the Blaini boulder-bed having been accepted as a reliable horizon of known age, "the sequence of strata below and above it in the Simla region became distributed accordingly along the standard stratigraphical scale: those below the Blaini-beds were regarded as Permian or older, and those above as Permian or younger."

This inference for a time seemed natural, but its acceptance was the cause of much difficulty, arising from the attempt to correlate the fossiliferous strata of Mesozoic and Tertiary age on the northern or Tibetan side of the crystalline axis with their presumed unfossiliferous equivalents on the south. It may be noted that more than one Indian geologist has had an eye to the possibility of finding in the Himalaya the counterpart of the great mass of unfossiliferous sedimentaries, so largely developed in Peninsular India, known as the *Purana*-group. As regards the beds above the Blaini boulders at Simla, any such correlation was impossible so long as these boulder-beds were held to synchronize with the Talchir boulder-bed.

The Director thinks that he sees a way out of the difficulty in the presumption that there has been more than one period of glaciation in times preceding the formation of the Talchir boulder-bed and its equivalents in South Africa and Australia. To prove this point he quotes the glacial boulder-beds held to exist below the Cambrian in South Australia, and he also believes that in South Africa there were two periods, preceding the Dwyka, where glacial phenomena are indicated. Moreover, on the coast of the Varanger Fjord, in Norway, glacial phenomena have been described by Reusch and Strahan in a formation which is presumably pre-Cambrian. Thus pre-Talchir boulder-beds are recognized in many quarters, and, whatever may be the value of this recognition as a proof of true glacial conditions in the respective periods, such recognition affords an alternative to the prevailing theory that the Blaini beds must be of Upper Carboniferous age. Hence the geologist will have a free hand in dealing with the unfossiliferous series above the Blaini formation at Simla.

W. H. H.

II.—The Geology of the Country between Newark and Nottingham. By G. W. Lamplugh, F.R.S., W. Gibson, D.Sc., R. L. Sherlock, B.Sc., and W. B. Wright, B.A. pp. vi, 126, with six text-illustrations and one plate of sections. 1908. Price 2*s.* 3*d.* Colour-printed map, Sheet 126; price 1*s.* 6*d.*

THE eastern side of the area described in this memoir consists of a belt of Lower Lias, with a gentle escarpment between Newark and Barnstone, along which the Rhætic beds outcrop. The central portion, occupied mainly by the Keuper marls, is traversed by the River Trent, which on its right impinges against the marls at Radcliffe and along the Trent Hills. To the west the ground is formed of Keuper waterstones and Bunter pebble-beds and sandstone, which extend from Nottingham northwards into Sherwood Forest. On the western margin there are fringes of Permian marls and Magnesian Limestone, which rest with marked unconformity on the Coal-measures.

Many points of considerable interest are dealt with in the memoir. Although the Coal-measures occupy a tiny and inconspicuous area at the surface, the question of their underground extent is of great importance; and Dr. Gibson, who deals with this subject, is able to bring the experience he has gained in Derbyshire and North Staffordshire to bear on the records of trial-borings. It is satisfactory to learn that the divisions established in those districts hold good in Nottinghamshire, and that the successive strata can be readily distinguished by their lithological and palæontological characters. Thus four marine bands in the chief coal-bearing series are found to maintain definite positions in the sequence. The divisions are shown in a useful table which gives particulars of the thicknesses of the strata and of the depths at which the chief coals occur. Borings have proved that Coal-measures occur beneath the Trias and Permian as far east as Thurgarton, where at a depth of 850½ feet the higher and unprofitable measures were reached, and they were penetrated to a total depth of 2,237½ feet without reaching the Top Hard Coal. That seam was, however, proved to the west, at Oxton at a depth of 2,026 feet and at Gedling at a depth of 1,375 feet; while the results of other borings to the south of Nottingham indicate that to the south and south-west of Thurgarton there is "a buried coalfield of great potentiality".

Mr. Sherlock's observations tend to show how closely linked are the Permian and Triassic deposits, as the Permian marl "appears to pass upward gradually into the Bunter by the intercalation of sandy material".

Deposits of economic importance are duly noted. The lower mottled sandstone of the Bunter yields moulding sand. The Permian and Keuper marls and the Lias Clay yield materials for brickmaking, while the Keuper marl has been used for the preparation of a top-dressing for cricket pitches and lawns. It furnishes also the important beds of gypsum worked at Newark and Orston.

The Lower Lias is noted for its hydraulic limestone which is worked in the basal beds at Barnstone. At a higher level, in the zone of *Ammonites semicostatus*, occur layers of ferruginous limestone of no economic importance, but on the horizon of the valuable iron-ore of Frodingham, in Lincolnshire.

Although the map accompanying this memoir is a Drift edition, the area covered by superficial deposits is remarkably small. There are a few patches of stony loam and gravel that are grouped by Mr. Lamplugh as glacial drift, the stony loam being coloured as Boulder-clay. This contains Bunter pebbles and occasional erratics, and part of it, west of Cotgrave, may be a direct product of glacial action; but other accumulations give the impression that they are rearranged relics of once existing glacial deposits.

Some of the older gravels along the Trent Valley may, in Mr. Lamplugh's opinion, belong to the closing stages of the Glacial period, but he finds no satisfactory evidence that the river was in existence prior to the great glaciation.

III.—Cyanide Processes. By E. B. Wilson. Fourth edition. pp. vii, 249, and 26 figures. New York, John Wiley and Sons; London, Chapman & Hall, 1908. Price 6*s.* 6*d.* net.

THE development of the cyanide process for the extraction of the precious metal when present in minute particles has had a most important bearing upon the gold industry. Without its aid many mines now profitably worked would have long since been abandoned. That gold was soluble in cyanide of potassium solutions has been known for more than a century past, but it is only within comparatively recent years that the method has assumed such a prominent position in mining practice. Although in simple cases the process is so exceedingly successful that the amount of gold which escapes is trivial, it cannot be applied blindly because certain minerals may be present in the ore which would hinder, if not entirely prevent, the extraction of gold. It is therefore necessary that the nature of the ore should first be studied and a suitable treatment devised to remove or render innocuous the cyanicides, as they may be termed.

In preparing this edition of his valuable manual, Mr. Wilson has taken the opportunity to add a chapter on the latest treatment of slimes, and has generally brought the information well up to date. It may safely be stated that the book is one which should be in the hands of anyone interested in the running of a cyanide plant. The procedure and the chemical reactions underlying it are fully explained, and the difficulties which may be encountered in the several processes receive ample discussion. Mr. Wilson keeps strictly to the point, and has wisely refrained from marring the usefulness of the book by overlading it with matter which concerns only the constructor of the plant and the engineer who erected it. In a future edition a few patent errors in the chemical equations call for amendment.

Mr. J. C. Jenkins gives in an appendix the treatment to be followed in a case of cyanide poisoning. Medical assistance may not be immediately forthcoming, and so rapid and fatal is this poison that the only hope lies in effective measures being promptly taken.

IV.—Devonian Fossils.

MR. J. G. HAMLING (*Trans. Devon Assoc.*, 1908, vol. xl, pp. 276–80) writes on "Recently-discovered Fossils from the Lower and Upper Devonian Beds of North Devon". He refers to the eastern side of Lynmouth Harbour, where fish-remains have been said to occur in abundance. After verifying the fact of their occurrence he subsequently obtained, in company with Mr. Upfield Green, a specimen identified as *Pteraspis* by Dr. A. Smith Woodward. Other important discoveries have also been made. On the eastern side of Lee Bay, west of Lynton, Mr. Hamling and Mr. Green obtained fish-remains; and also *Spirifer primævus*, *S. sub cuspidatus*, *S. speciosus*, and *Orthotetes umbraculum*, Brachiopods not previously recorded from the locality. It is noted that "the discovery of *Spirifer primævus* (a Taunusian form) in the Lynton Beds is an unexpected corroboration of Mr. W. A. E. Ussher's homotaxial correlation of these beds with those of the Meadfoot group, in which the Taunusian is included". Again, as "the

Dartmouth slates are homotaxially correlated with the Foreland grits, the discovery of *Pteraspis* materially strengthens this correlation, as Mr. Ussher has shown that these remains are not restricted to the Dartmouth slates proper, but range up into dark slates presumably belonging to the Meadfoot group". Our attention was called some time ago by Mr. Upfield Green to the title of a paper read before the Geological Society on November 23, 1870, "On the Discovery of a 'Bone Bed' in the lowest of the 'Lynton Grey Beds', North Devon," by F. Royston Fairbank, M.D. The title only was printed in the Quarterly Journal (1871, vol. xxvii, p. 33), the paper having been withdrawn. The abstract, however, with the discussion, appeared in the Geological Magazine for January, 1871, p. 38. Mr. R. H. Valpy then stated that he had recognized similar beds along the coast of North Devon, an account of which had already been published at Ilfracombe. (See his *Notes on the Geology of Ilfracombe*, printed by Twiss & Sons, Ilfracombe, no date.)—H. B. W.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

1.—*January* 13, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The President announced that the Council, at its meeting that afternoon, had passed the following resolution:—

"The Council of the Geological Society desires to express to the relatives of Professor H. G. Seeley, F.R.S., its profound sorrow in the death of one who had been a Fellow for nearly half a century, had frequently served on the Council of the Society, and for so many years continued to enrich the literature of Geology and Palæontology by numerous original researches in these Sciences."

The following communications were read:—

1. "On Labradorite-Norite with Porphyritic Labradorite." By Professor Johan H. L. Vogt, F.M.G.S.

This paper deals with a rock occurring at Napp Farm, on Flakstadö, off the northern coast of Norway. It contains 23 per cent. of labradorite-phenocrysts, in a crystalline groundmass made up of a more acid plagioclase, hypersthene, diallage, and titano-magnetite, with small quantities of biotite, and very little spinel, apatite, and pyrite. A little secondary hornblende and some garnet are present, but few other secondary products. Olivine is conspicuously absent.

The plagioclase-phenocrysts are more acid in their outer zones, and the groundmass plagioclase is still more acid as determined optically and by specific gravity and analysis. Analyses are tabulated of the bulk of the rock and the groundmass and of the separated plagioclases and the magnetite. From these the relative proportions of the constituents are calculated and the formula of the felspars determined; also the titano-magnetite proves to be a mixture of magnetite with ilmenite.

The order of crystallization is found to be: (1) Phenocryst plagioclase; (2) plagioclase with magnetite; and (3) plagioclase, magnetite, pyroxenes. The plagioclase-phenocrysts started to form at

points from 8 to 18 centimetres apart, and when they had grown to some size a second crop of smaller crystals grew at nearer points; the magnetite was much aggregated round the plagioclase-phenocrysts, growing together with the plagioclase of the groundmass; and finally the remaining magma crystallized. The order of crystallization is found to be consonant with the physico-chemical laws applying to the phase liquid-solid. Graphic representations are given to illustrate the order of crystallization of a ternary system of plagioclase, magnetite, and pyroxene; and it is shown that the separation of such a system would yield first the formation of plagioclase-phenocrysts; secondly, the solidification of a magnetite-plagioclase eutectic; and finally an eutectic of plagioclase, magnetite, and pyroxene. In considering the equilibrium between the solid and the liquid albite-anorthite phase, it is found that equilibrium must have been maintained sufficiently long for the phenocrysts to acquire a composition different from the first-formed crystals, but that eventually the equilibrium broke down, a matter possibly connected with the size of the phenocrysts in relation to the viscosity of the solution. The history of events in connection with the pyroxenes was probably similar to that in the case of the plagioclases, but this portion of the subject is not fully worked out. The temperature interval of crystallization is estimated to have been between about 1400° and 1000°.

The author considers that this investigation establishes that the processes of crystallization in a magma may be explained in all details according to physico-chemical laws.

2. "On the Genus *Loxonema*, with Descriptions of New Proterozoic Species." By Mrs. Jane Longstaff (*née* Donald), F.L.S. (Communicated by Dr. G. B. Longstaff, M.A., F.G.S.)

There is some confusion with regard to the type of the genus *Loxonema*, which has arisen from the confounding of the Silurian *Terebra* (?) *sinuosa* of Sowerby with the Devonian form which Phillips called *L. sinuosum*. This matter is discussed, and the author, following Lindström, Koken, and Perner, takes *L. sinuosum*, Sowerby, as the type in the absence of sufficient reasons to the contrary. If this be done, the other two types mentioned by Phillips cannot remain in the genus, one belonging to the genus *Macrocheilina* and the other to *Zygopleura*. This paper deals simply with Ordovician and Silurian species, therefore only a few subgenera are referred to—*Rhabdostropha*, Don., and *Stylonema*, Perner.

The diagnosis of *Loxonema* is amended, and a note given as to the true range and the geographical distribution of the genus. Descriptions are given of *L. sinuosum*, Sow., of *L. intumescens*, Lindstr., and of *L. striatissimum*, Salt. MS., and six new species and one new variety are described of this genus. *R. pseudofasciatum*, Don., and *R. Grindrodi* and a new species of this subgenus from Stoke Wold in the Lower Ludlow Beds are next described. This is followed by a description of two new species of the subgenus *Stylonema*, one from the Chair of Kildare and the second from Mulloch Hill. In conclusion, a new species of *Hormotoma* from the Llandeilo Flags of Builth Bridge is described.

2.—*January* 27, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Conway Succession." By Miss Gertrude L. Elles, D.Sc. (Communicated by Dr. J. E. Marr, F.R.S., F.G.S.)

In this area the author has found a complete succession of strata, from Llandeilian up to Salopian date. The divisions proposed are as follows:—

			Zone of
Salopian.	Benarth Flags and Grits	. .	*Cyrtograptus symmetricus.* *Monograptus riccartonensis.* *Cyrtograptus murchisoni.*
Valentian.	Gyffin Shales. (300 feet.)	. .	*Monograptus crenulatus.* *Monograptus crispus.* *Rastrites maximus.* *Monograptus sedgwicki.* *Monograptus gregarius.* *Mesograptus modestus.*
	Conway Castle Grits. (150 feet.)		
Ashgillian.	Deganwy Mudstones. (30 feet.)	.	*Phacops mucronatus* and *Dicellograptus anceps.*
	Bodeidda Mudstones. (350 feet.)		*Trinucleus* Beds.
Caradocian.	Cadnant Slates (Upper)	. . .	*Dicranograptus clingani.* *Climacograptus wilsoni.*
Llandeilian.	Cadnant Slates (Lower). (310 feet.)		*Dicranograptus brevicaulis* and *Mesograptus multidens.* *Climacograptus peltifer.*
Conway Mountain Volcanic Series.	Upper or Coetmor Ash Group.		
	Upper Brecciated Lava Group. (710 feet.)		
	Lower or Bodlondeb Ash Group. (60 feet.)		
	Lower Banded Lava Group. (1,400 feet.)		

After references to the literature and an account of the landscape and structure of the district, the beds are described in ascending order, lists of fossils being given from the more important exposures. The sections show that there is no break whatever in the sequence between the Ordovician and the Silurian rocks in the district. Petrological notes on the chief igneous rocks are given, and then a detailed comparison is established between the rocks of this area and those of South Wales, the Rhayader and Tarannon districts, Lakeland, the South of Scotland, and Pomeroy. The Conway Mountain Volcanic Series appears to be equivalent to the Borrowdale volcanic rocks of the Lake District, and the Cadnant Slates and Bodeidda Mudstones equivalent to the Upper *Dicranograptus* Shales, *Trinucleus* Beds, and Sholeshook Limestone of South Wales, the Sleddale and Roman Fell Groups of Lakeland, and the Upper Glenkiln and Lower Hartfell of the South of Scotland. The Deganwy Mudstones are paralleled with the Redhill Beds and the Ashgill Shales. Close comparison is possible between the graptolitic zones of the Gyffin Shales and corresponding beds at Rhayader, Tarannon, in the Lake District, and the South of Scotland. Finally, the Benarth Flags are compared with the Brathay Flags, the Riccarton Beds, and beds above and including *Cyrtograptus murchisoni* in the Tarannon district.

2. "The Depth and Succession of the Bovey Deposits." By Alfred John Jukes-Browne, B.A., F.G.S.

The total thickness of the Tertiary Beds in the Bovey Basin has never yet been ascertained, because no boring has yet reached the bottom of the basin in which they lie; and no one has yet attempted to make out a stratigraphical succession from the sections exposed in the numerous clay-pits.

Some years ago, however, Messrs. Candy & Co., of the Heathfield Potteries, put down a boring which reached a depth of 526 feet from the surface. Having obtained some particulars concerning the beds traversed by this boring, the author is able to discuss the succession of the Bovey deposits, so far as they have been explored. The following is a generalized description of the strata seen in the Heathfield pit, and penetrated by the boring from the bottom of that excavation:—

	Thickness in feet.
Superficial deposits	about 20
Beds of clay and sand, with occasional beds of lignite . .	250
Beds of lignite and clay, with one of sand	36
Beds of lignite, with thin layers of clay	220½
	526½

The author confirms the conclusion arrived at by Pengelly in 1861, with regard to the relative age of the beds exposed in the 'old coal-pit' south-east of Bovey Tracey and those proved in a boring to the east of it. From all the data mentioned, and assuming the actual base of the Tertiary deposits to be not more than 30 feet below the bottom of the Heathfield boring, he estimates the total thickness of the 'Eocene' beds to be about 613 feet.

The Bovey Basin itself is regarded as a tectonic basin or post-Eocene pericline, and not as a lake-basin; although, during the deposition of the higher part of the series, it may have formed part of a large lacustrine or lagoon area, extending over the greater part of East Devon.

The author dissents from Heer's view of the manner in which the lignites were formed, discusses the identification of some of the plants, and concludes that the lignites which form the mass of the lower beds represent the growth and decay of successive swamp-forests, similar to that of the Great Dismal Swamp of Virginia at the present day.

Assuming that these lower beds are of Eocene age, and contemporaneous with the Bournemouth Beds of the Hampshire Basin, the author points out that nothing has yet been proved with regard to the higher beds, which may be of Bartonian or even of Oligocene age.

3.—*February* 10, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The President announced that the Council, at its meeting that afternoon, had passed the following resolution:—

"The Council of the Geological Society records its sense of the very great loss which the Society sustains from the death of Mr. W. H. Hudleston, F.R.S. By his distinguished services as President and as Secretary, by the constant interest which he took in the Society's affairs, and by the distinction of his high scientific

reputation, he had laid the Society under a deep obligation. The Council desires to express to Mrs. Hudleston the sincere sympathy of the Society in her bereavement."

The following communications were read:—

1. "Note on some Geological Features observable at the Carpalla China Clay Pit in the Parish of St. Stephen's (Cornwall)." By Joseph Henry Collins, F.G.S.

An east-and-west fault traverses this pit near its southern wall, with a downthrow to the south of more than 50 feet. North of the fault there is china clay rock or 'carclazyte', at one point underlying granite not sufficiently altered to yield china clay, and sometimes containing embedded lenticles or irregular masses of partly kaolinized granite. The carclazyte is often traversed by veins of secondary quartz, in most instances associated with schorl. It also contains lepidotite, gilbertite, topaz, fluor, and schorl. South of the fault there is nearly horizontal tourmaline schist, at one point 50 feet thick, and thinning off southwards and eastwards. This, like the rock of the north side, is overlain by subsoil or 'growan', covered in turn by soil or 'meat-earth'. Underlying the schist there occurs also china clay rock to a distance of many fathoms from the fault. This occurrence of china clay under a thick schistose overburden is unique in Cornwall, although the other features of the pit are reproduced elsewhere. The author considers that this example is strongly in favour of the pneumatolytic origin of carclazyte, the gases producing the change being possibly in part carbonic acid, but probably to a more important degree chlorine, fluorine, and boron.

2. "Some Recent Observations on the Brighton Cliff Formation." By Edward Alfred Martin, F.G.S.

The author records in his paper certain features presented by the face of the cliffs between successive falls at Black Rock, Brighton, during the past eighteen years. As the cliffs have worn back, the base-platform of Chalk grows in height, and the layer of sand which Prestwich found above the Chalk grew thinner and thinner until finally it completely disappeared. At the same time the raised beach has grown in thickness from 1½ to 12 feet. In 1890 there were 6 feet of sand, with a foot and a half of beach above it. There was practically no protection at this date in the shape of groynes. In 1892 the sand had decreased to between 3 and 4 feet, but the beach remained as in 1890. Many falls of cliff took place between 1892 and 1895, and at the latter date the beach had increased to between 4 and 5 feet. The eastern limit of the beds had become more clearly defined, the trough in the Chalk in which they had been defined taking an upward direction about 300 yards east of the Abergavenny Inn. Many blocks of red sandstone had become dislodged, and were lying on the modern beach. In 1897, 10 feet of chalk formed the lower portion of the cliff, with 8 feet of raised beach above it in places, but there was a mere trace of sand left. The rubble drift above was seen to be distinctly stratified. Many masses of red sandstone had fallen out of the cliff, the largest measuring 5 feet in its greatest dimension. In 1899 the raised beach had reached a thickness of 10 feet. Great masses of moved and reconstructed chalk were observed on the eastern boundary embedded in the beach. Two rounded lumps of granite

were extracted from the beach. In 1903 the beach was but a little over 8 feet thick in the exposed parts, but the platform of chalk was 14 feet thick. The upper portions of the beach, which were the least consolidated, had fallen away in such a manner as to leave cave-like gaps beneath the rubble. The number of red sandstone blocks which lay on the modern beach was remarkable, forty such blocks being counted in a space of 50 yards square. In 1906 the raised beach had increased from 15 to 20 feet; farther west, however, the thickness was not so great. In 1908 there were 17 feet of chalk, 12 feet of beach. It is noteworthy that as the degradation of the cliff proceeds, the material is rapidly carried away by the sea. No talus remains for any length of time, and if the material is to be prevented from disappearing into deep water, some such contrivance as chain-cable groynes seems to be demanded, fixed somewhere between low and high tide-marks. The only organic remains observed in the cliffs were some fragments of shells, found at the top of the raised beach.

At a Special General Meeting held at 7.45 p.m. before the Ordinary Meeting, the following resolution was proposed by Dr. A. Smith Woodward, F.R.S., and seconded by Dr. R. D. Roberts:—

"That it is desirable, under the existing Charter, to admit Women to candidature for the Fellowship of the Society, on the same terms as men."

A ballot having been asked for, the resolution was rejected by 50 votes to 40.

II.—Mineralogical Society.

Tuesday, January 26.—Dr. A. E. H. Tutton, F.R.S., Vice-President, in the Chair.

(1) On the identity of poonahlite with mesolite; by Dr. H. L. Bowman. Small colourless prisms, associated with stilbite and pale-green apophyllite from Poonah, which appear to be identical with the mineral described by H. J. Brooke in 1831 as poonahlite, are shown by analysis to be mesolite having a composition corresponding to a mixture of two molecules of scolecite with one of natrolite. The optical characters are similar to those recently observed by Görgay in mesolite from the Faroe Islands.—(2) Cross-planes in twin-crystals; by Dr. J. W. Evans. A twin-plane is composed of two equivalent planes, one from each component crystal, and every line in it is composed of two equivalent lines. A cross-plane is also composed of two equivalent planes, but there are only two, four, or six lines (at right angles in pairs) composed of equivalent lines. A plane of composition is always a twin-plane or a cross-plane. In the former molecular distances are the same in all directions in the plane; in the latter in two, four, or six directions only.—(3) Comparison of the refractive indices of adjoining crystals in a rock slice which have their directions of vibration oblique to one another; by Dr. J. W. Evans. The nicols are placed with their directions of vibration parallel and bisecting the angle θ between the directions of the vibrations whose refractive indices are to be compared. The light received from these directions will (apart from interference) be proportional to $\cos^2 \frac{\theta}{2}$, and that from

those at right angles to them to $\sin^2 \frac{\theta}{2}$, so that the former will bear to the latter the ratio $\cot^2 \frac{\theta}{2}$. If θ be less than 35°, this will be greater than 10, and the light from the directions at right angles may be neglected both in respect of its direct effects on the Becke phenomena and its indirect action in producing interference.—(4) Note on the spontaneous crystallization of solutions as spherulites; by Mr. J. Chevalier. Experiments on solutions of potash-alum, sodium, ammonium, and lithium sulphates, etc., made at the suggestion of Professor Miers in the Oxford Mineralogical Laboratory, show that spherulites and sphero-crystals are characteristic of the spontaneous crystallization of many solutions in thin drops. When other crystals grow first, it is probably because they have been introduced, the drop in that case appearing to be metastable. The spherulites mark the passage of the solution to the labile state.—(5) On a method for studying the optical properties of crystals; by the late Dr. H. C. Sorby. The author gives complete details of his work on the determination of refractive indices in thin plates, of which preliminary accounts have been published in the first two volumes of the *Mineralogical Magazine*. The method he describes in the case of doubly refractive minerals is identical in principle (though devised quite independently) with that given by the Duc de Chaulnes for singly refractive substances, but is worked out in far greater detail.—(6) Some additional localities for idocrase in Cornwall; by Messrs. G. Barrow and H. H. Thomas. During the mapping of the metamorphic area round the Bodmin Moor granite further occurrences of idocrase have been found in the altered limestones. Well-shaped crystals of the mineral, up to 6 mm. in length, are fairly common in drusy cavities. They are perfectly uniaxial, but show in thin sections considerable variation in the double refraction, especially in the outer layers of the crystals. The idocrase is associated with pale-pink to pinkish-brown garnet (often in regular intergrowth with the idocrase), pale-green diopside, and epidote approximating to clinozoisite in its low extinction and birefringence.—(7) Detrital andalusite in Tertiary and post-Tertiary sands; by Mr. H. H. Thomas. Occurrences of detrital andalusite are described in sands from various localities in West Wales. In no sedimentary rock of greater antiquity than the Pliocene has detrital andalusite been found. In the sands of West Wales the mineral occurs as slightly elongated, somewhat angular grains, often showing very intense pleochroism from blood-red to pale greenish blue. It is associated in these sands with pink garnet, greenish-brown augite, cyanite, zircon, rutile, tabular anatase, staurolite, brown and more rarely blue tourmaline, green hornblende, bright-green epidote, cordierite, iron-ores, and in some cases glaucophane.—(8) The energy of twin-crystals; by Mr. H. Hilton. The author determines in a simple case the conditions according to which a twin-crystal may be a more stable form, or in other words may have less surface energy, than a simple crystal of the same volume. —Mr. Hutchinson exhibited a new protractor devised by Dr. V. Goldschmidt.

CORRESPONDENCE.

SOLUTION THEORY OF VALLEY FORMATION.

SIR,—In the December number of the GEOLOGICAL MAGAZINE there appeared a short article by Mr. Jukes-Browne on the subject of the solution theory of valley formation as applied by the Rev. E. C. Spicer to the area of the Glyme and Dorne. It seems to me that there are several points in this paper that demand some attention.

It is said that Mr. Spicer's proposition "assumes that the rocks of the district are traversed by a double set of joints which coincide approximately with the winding of the streams, but no evidence is adduced to prove that this is actually the case, and his own map shows that the windings of the Glyme and Evenlode are so irregular that they cannot be reduced to the intersection of two sets of lines. This map is reproduced, so that the reader can judge for himself". I have studied the map in question, and also traversed the ground several times, twice under the guidance of Mr. Spicer. Though the map was not drawn with that intention, it seems to me to show very clearly the tendency of the Evenlode, Dorne, and Glyme to twist in right angles, and so indicate a set of lines which may well coincide with joints. It is a very suggestive fact that where the Evenlode runs across the Lias this tendency appears to vanish.

No one who looked at the question impartially would expect to find a network of joints accurately indicated by valleys in such an 'advanced' stage as those of the Evenlode, Dorne, or Glyme. The right angles are practically gone from the Cherwell Valley, but are very characteristic of many of the valleys in the area under discussion which are still dry, and are shown by such 'embryo' solution valleys as may be seen near Wooton and (outside the area) at Cuddesdon.

A little further on we read that "on this [Mr. Jukes-Browne's] view it is easy to understand why there is only one valley system, but if Mr. Spicer's theory were correct we ought to find traces of an ancient system of mechanically formed valleys which did not coincide with the subsequently formed 'solution valleys' ". We do find traces of such a system. The most noticeable instance is described by Mr. Pocock in the Geological Survey Memoir on the country round Oxford, under the name of the 'Wilcote Valley' (p. 92). While the covering of Oxford Clay was still nearly continuous over the area, the Windrush joined the Evenlode near Ashford Mill, a fact which is of great importance in considering the 'misfit' of the Evenlode. As the clay was removed a solution valley was developed which finally broke into the Windrush Valley and led it into the present course past Witney. But the pre-solution mechanically formed valley between Wilcote and Northleigh remains, flanked on the south by the outliers of Oxford Clay alluded to by Mr. Jukes-Browne.

The part played by landslips in the formation of valleys has certainly received little attention. That many of the chalk valleys are frequently widened by small slips no one who knows them will deny; it is possible, too, that slips may occasionally serve to lengthen such valleys, but for obvious reasons they can neither initiate nor deepen them.

Mr. Jukes-Browne has pointed out that the solution theory requires (1) a previous series of valleys formed in the clay, which has now largely disappeared, by mechanical surface action, of which series we might expect to find traces; (2) that there should be some indication in the present valleys, supposed to be due to solution, of two sets of joints in the limestones.

I have endeavoured to point out that we find both of these requirements in the Evenlode–Glyme area.

C. N. Bromehead.

University Museum, Oxford.
January 19, 1909.

OBITUARY.

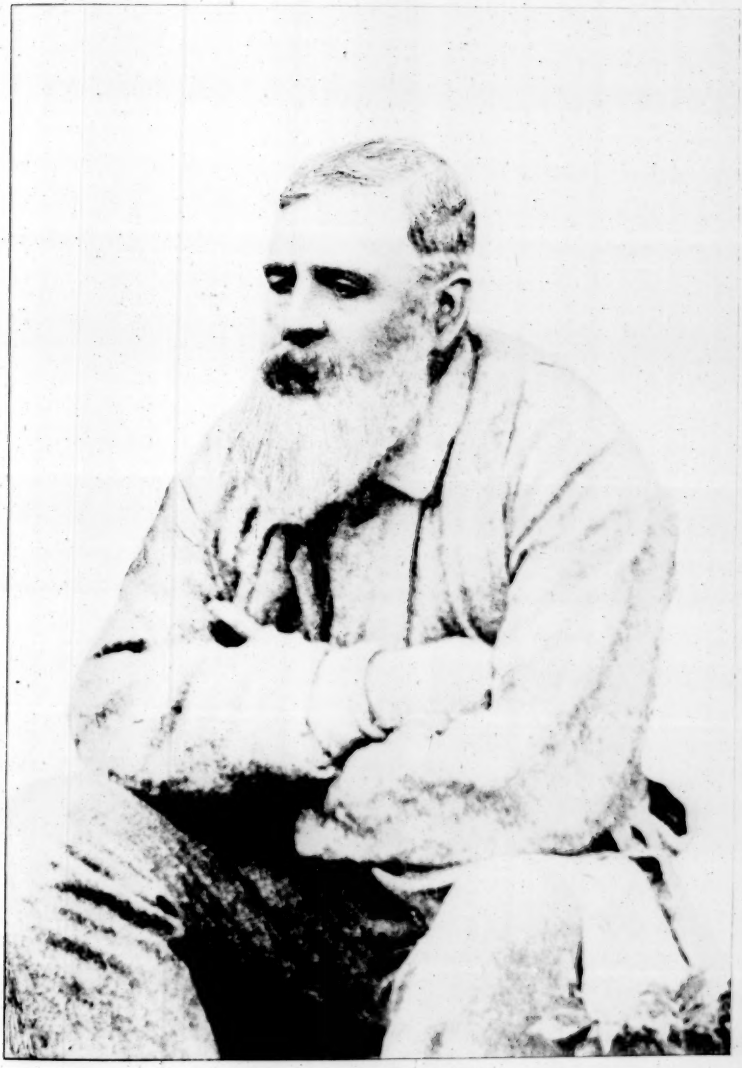
GEORGE HENRY KINAHAN, M.R.I.A.

Born December 19, 1829. Died December 5, 1908.

(PLATE V.)

We regret to record the death at Fairview, Dublin, in his 79th year, of G. H. Kinahan, one of the most distinguished of Irish geologists. The son of Daniel Kinahan, M.A., Barrister-at-Law, he was educated at Trinity College, Dublin, and having qualified as a civil engineer, in 1853 he had conferred on him the Diploma in Engineering of the University. His first professional engagement was on the staff employed on the viaduct which spans the Valley of the Boyne at the harbour of Drogheda, on behalf of the Dublin and Belfast Junction Railway Company, now merged in the Great Northern Railway. Sir John Macneill and James Barton were the chief engineers. This lattice bridge was the second of its kind built in Ireland. In 1854 Kinahan was appointed to the Irish Branch of the Geological Survey of the United Kingdom, under Sir Roderick I. Murchison, K.C.B., Director-General, Professor J. Beete Jukes being then the Local Director for Ireland. He was promoted Senior Geologist in 1861, District Surveyor in 1869, and retired after thirty-six years service in 1890. His official work extended to almost every county in Ireland, and his name appears on twenty-six of the official "Memoirs of the Geological Survey of Ireland". He was a voluminous writer from the time he joined the Survey. His contributions to the Journal of the Geological Society of Dublin (afterwards the Royal Geological Society of Ireland) extend from 1859 to 1889, articles from his pen appearing in every volume during these years; and he delivered as President the Anniversary Addresses in 1880 and 1881 before that Society. He was a member of the Council of the Royal Irish Academy and a contributor to its Proceedings.

As an archæologist he contributed many papers on Crannoges, Megalithic monuments, and other cognate subjects to the Kilkenny and South-East of Ireland Archæological Society and to the Royal Historical and Archæological Association of Ireland. Other papers by him were published by the Geological Societies in Edinburgh, Manchester, Liverpool, and Glasgow; by the Institute of Civil Engineers, Ireland, and the North of England Institute of Mining and Mechanical Engineers. The British Association, of which for many years he was one of the General Committee, received his last written article for the 1908 meeting in Dublin, on the "Raised Beaches of the



G. H. KINAHAN, M.R.I.A.

LATE OF THE GEOLOGICAL SURVEY OF IRELAND.

Born December 19, 1829. Died December 5, 1908.

Liffey Valley". He frequently wrote in the *Irish Naturalist*; and to the GEOLOGICAL MAGAZINE, from the first volume in 1864 to 1888, he contributed no fewer than 85 papers. Besides his numerous articles, many hundreds in number, his principal separate publications were *Manual of the Geology of Ireland* (1878); *Valleys, and their relation to Fissures, Fractures, and Faults* (1875); *Handy Book of Rock Names* (1873); *A Handy Book on the Reclamation of Waste Lands in Ireland*; and *Superficial and Agricultural Geology, Ireland* (1908).

No one had so extensive a knowledge of Irish geology as Kinahan, and he was especially acquainted with the practical side of the science, as shown in the important papers he communicated to the Scientific Proceedings of the Royal Dublin Society on the Economic Geology of Ireland.

He is to be regarded as one of the last of that brilliant band of pioneers in the Irish School of Geology that included Griffith and Portlock, Jukes, Haughton, and Maxwell Close, whose meetings attracted hundreds of Dublin citizens to learn the story of the building of their island, and to ponder upon the interesting problems which they could so conveniently study near their city.

His remains were interred in the quiet country churchyard on the hillside near the meeting of the waters in the Vale of Avoca, a district which was one of his latest stations when on active service on the Geological Survey.

H. LEONARD and R. CLARK.

WILFRID H. HUDLESTON, J.P., M.A., F.R.S., F.L.S., F.G.S., F.C.S., ETC.

BORN JUNE 2, 1828. DIED JANUARY 29, 1909.

AMONG the numerous fellow-workers in science lost to us in the closing months of the old and the opening of the new year, the death of none has been more keenly felt than that of Mr. Hudleston, our friend and co-editor in this Magazine since 1886.

Educated at Uppingham School he subsequently entered St. John's College, Cambridge, where he graduated B.A. in 1850. Although attracted by Professor Sedgwick's lectures he did not take up geology in earnest until he came under the influence of Professor Morris in 1866. His earlier years were devoted to the study of the Law, and he was called to the Bar in 1853, but never practised. Attracted by Professor Alfred Newton, of Cambridge, and Mr. John Woolley, Hudleston (who at that time was Wilfrid Simpson) took up the pursuit of ornithology, visiting Lapland in 1855, and subsequently exploring the Eastern Atlas range and Algeria in company with Canon Tristram and Mr. Osbert Salvin. Afterwards he spent a year travelling and collecting in Greece and Turkey. From 1866 to 1886 he devoted close attention to the study of geology with John Morris. In 1867 (having taken the name of Hudleston) he was elected a Fellow of the Geological Society. From 1886 to 1890 he served the office of Secretary, and from 1892 to 1894 he occupied the Presidential Chair, receiving the award of the Wollaston Medal in 1897. Mr. Hudleston was President of the Geologists' Association 1881–3, and both by his writings and his conduct of many of its excursions he won the lasting gratitude of the Association. Mr. Hudleston's